The NorthMet Project would create an open pit copper, nickel, cobalt and precious metals mine with adjacent stockpile areas; refurbish a portion of the former LTV Steel Mining Company (LTVSMC) processing plant and construct a new hydrometallurgical facility at the plant site; construct a new tailings basin facility on the site of LTVSMC tailings facilities; and add to existing utility infrastructure and rail lines. The open pit mine, waste rock stockpiles and other mine-site facilities would disturb around 1,400 acres. The least reactive waste rock would be stored in a permanent stockpile adjacent to the mine. The most reactive waste rock would be stored temporarily in lined surface stockpiles and then backfilled into the mine pit and permanently stored under water. Ore processing would take place at the former LTV Steel Mining Company's taconite ore processing plant. The plant would need to be refurbished and modified to process base and precious metal sulfide ore. PolyMet has estimated the project would have direct impacts on about 900 acres of wetlands. Most of these wetlands at the mine site abut the Partridge River, which is part of a tributary system to Lake Superior. T

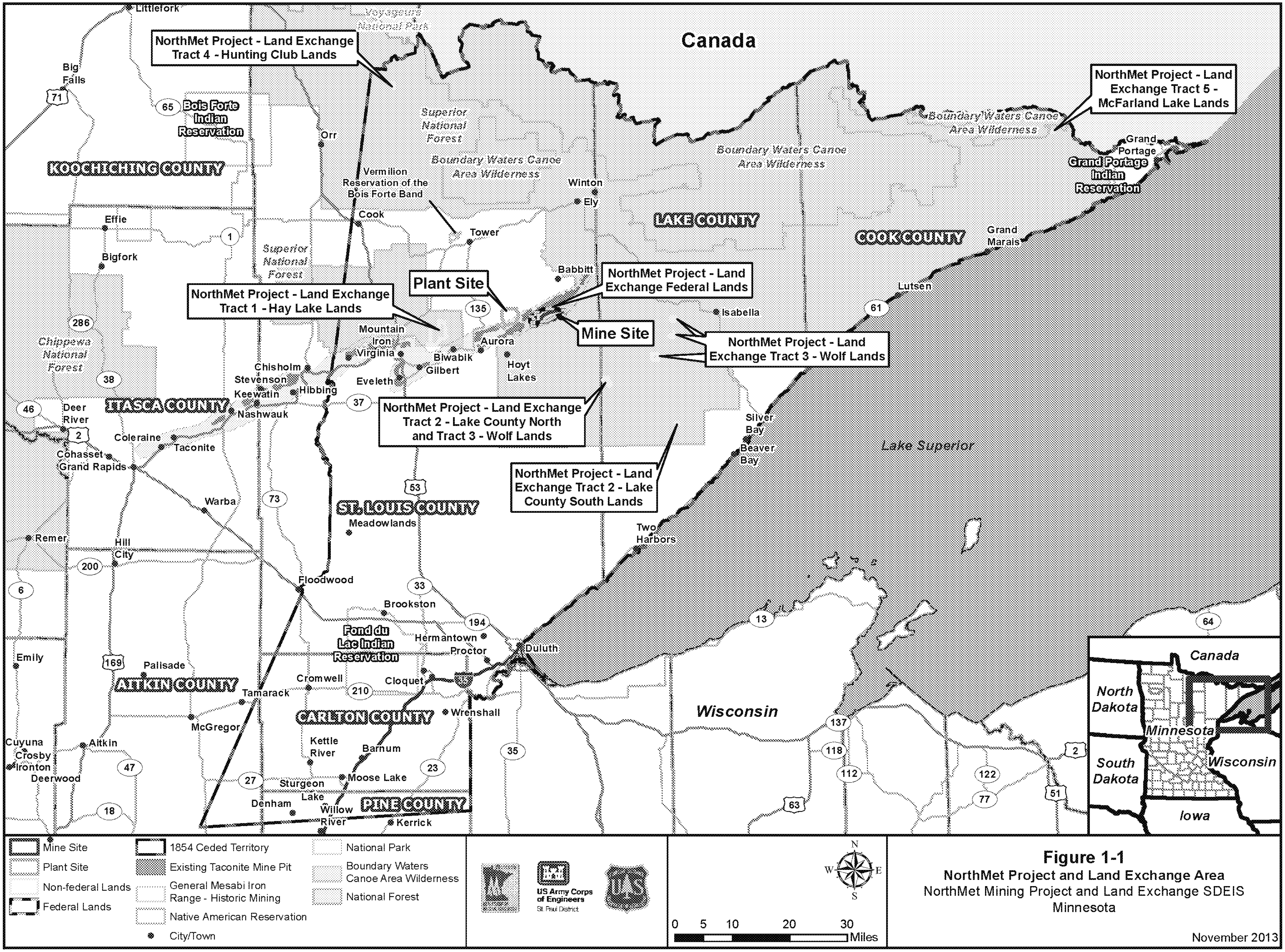


Figure 1-1
NorthMet Project and Land Exchange Area
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

November 2013

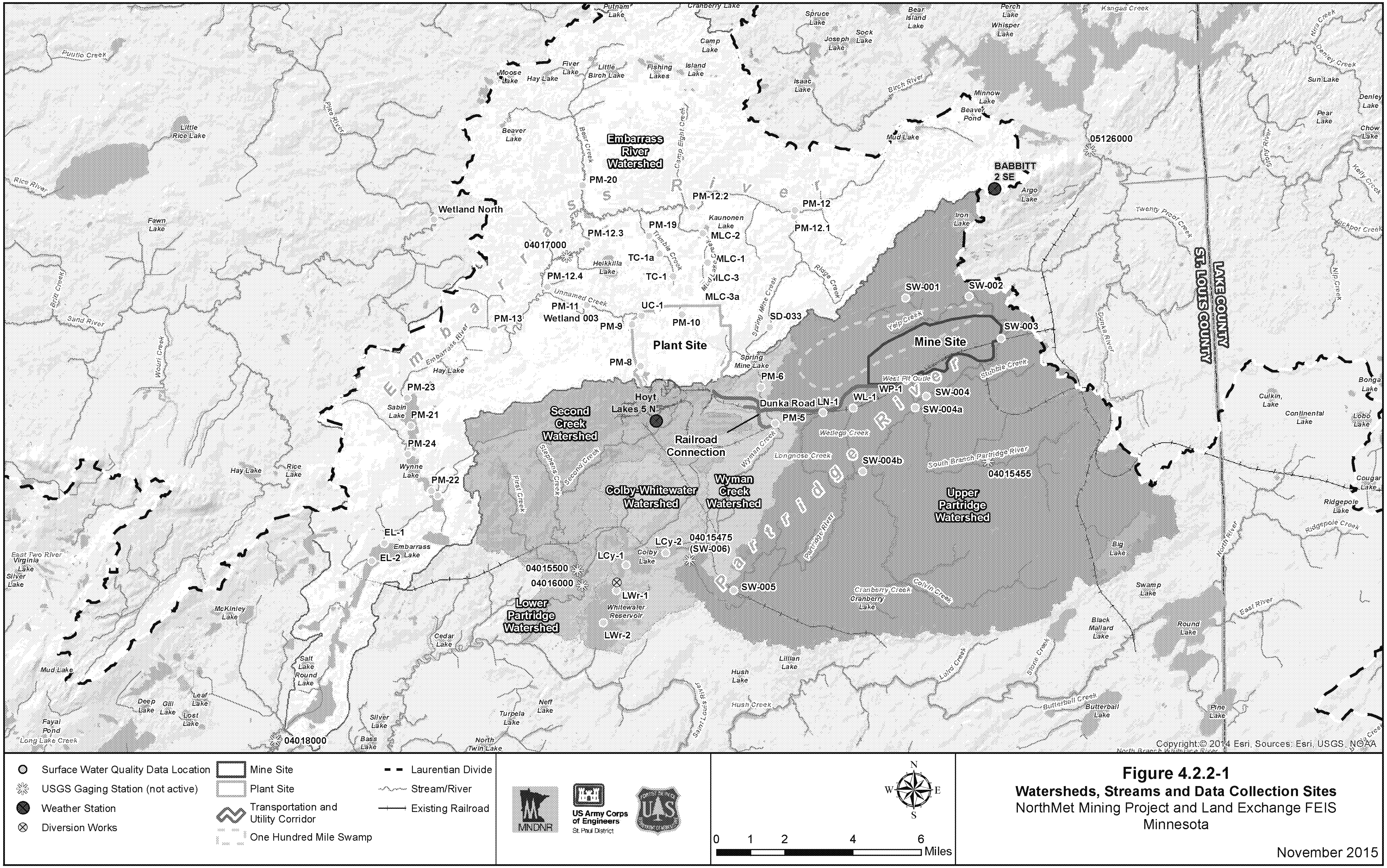
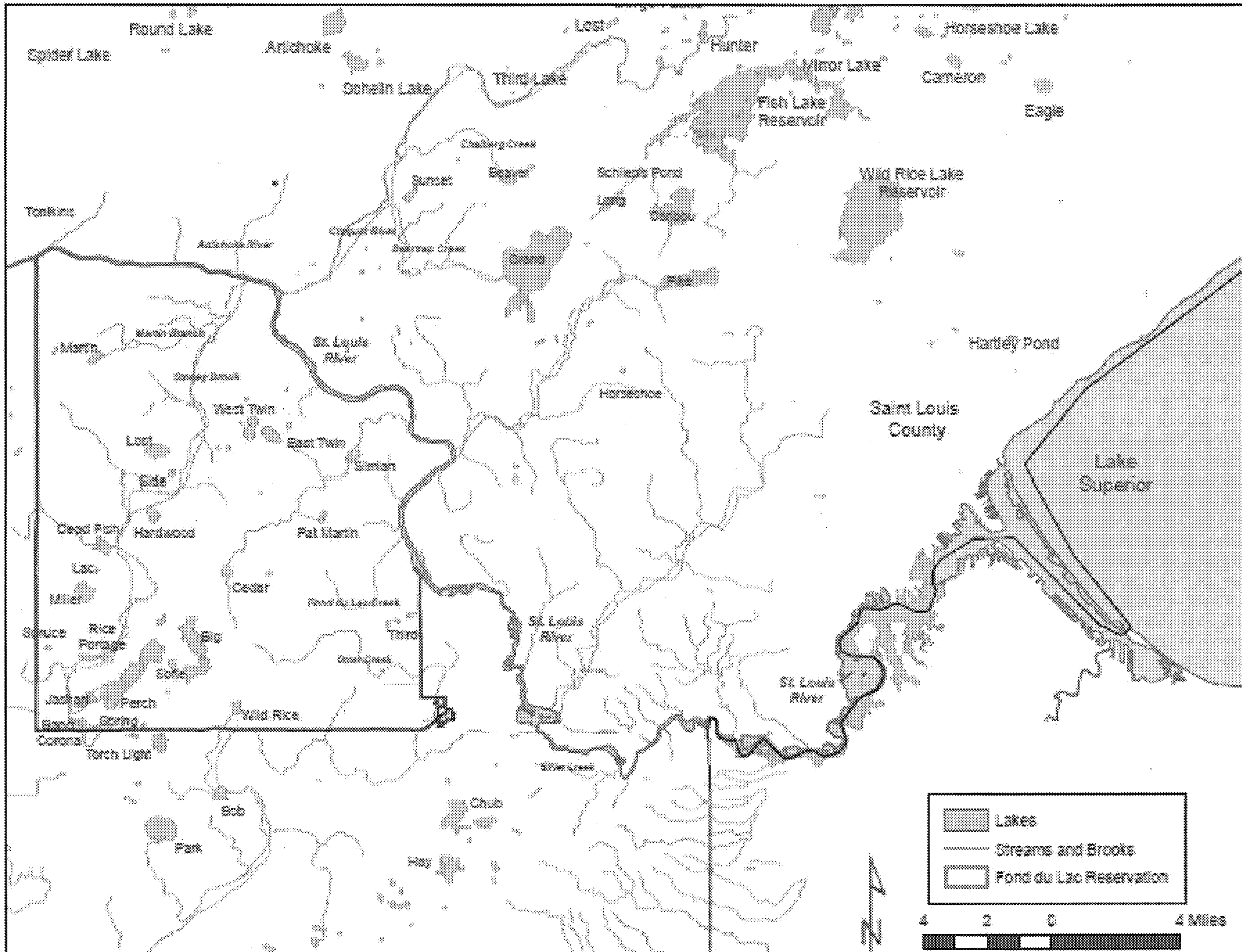


Figure 4.2.2-1
Watersheds, Streams and Data Collection Sites
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015


Round Lake
Spider Lake
Artichoke
Schelin Lake
Lost
Hunter
Third Lake
Horseshoe Lake
Mirror Lake
Cameron
Fish Lake
Reservoir
Eagle
Sunset
Beaver
Schlepps Pond
Wild Rice Lake
Reservoir
Tomkins
Grand
Pike
St. Louis
River
Hartley Pond
Martin
West Twin
East Twin
Horseshoe
Saint Louis
County
Lake
Superior
Lost
Simian
Side
Dead Fish
Hardwood
Pat Martin
Lac
Cedar
Miller
Spruce
Rice
Portage
Big
Third
St. Louis
River
Soft
Jaskari
Perch
Wild Rice
St. Louis
River
Spring
Corona
Torch Light
Chub
Bob
Park
Hay
Lakes
Streams and Brooks
Fond du Lac Reservation
N
4
2
0
4 Miles

MDNR Designated Public Waters Inventory (PWI) Stream/River

Non MDNR Designated Public Waters Inventory (PWI) Stream/River

MDNR Designated Public Waters Inventory (PWI) Lake/Wetland

Mine Site

Plant Site

Transportation and Utility Corridor

MNDNR

US Army Corps of Engineers St. Paul District

N W E S

0 0.5 1 2 3 Miles

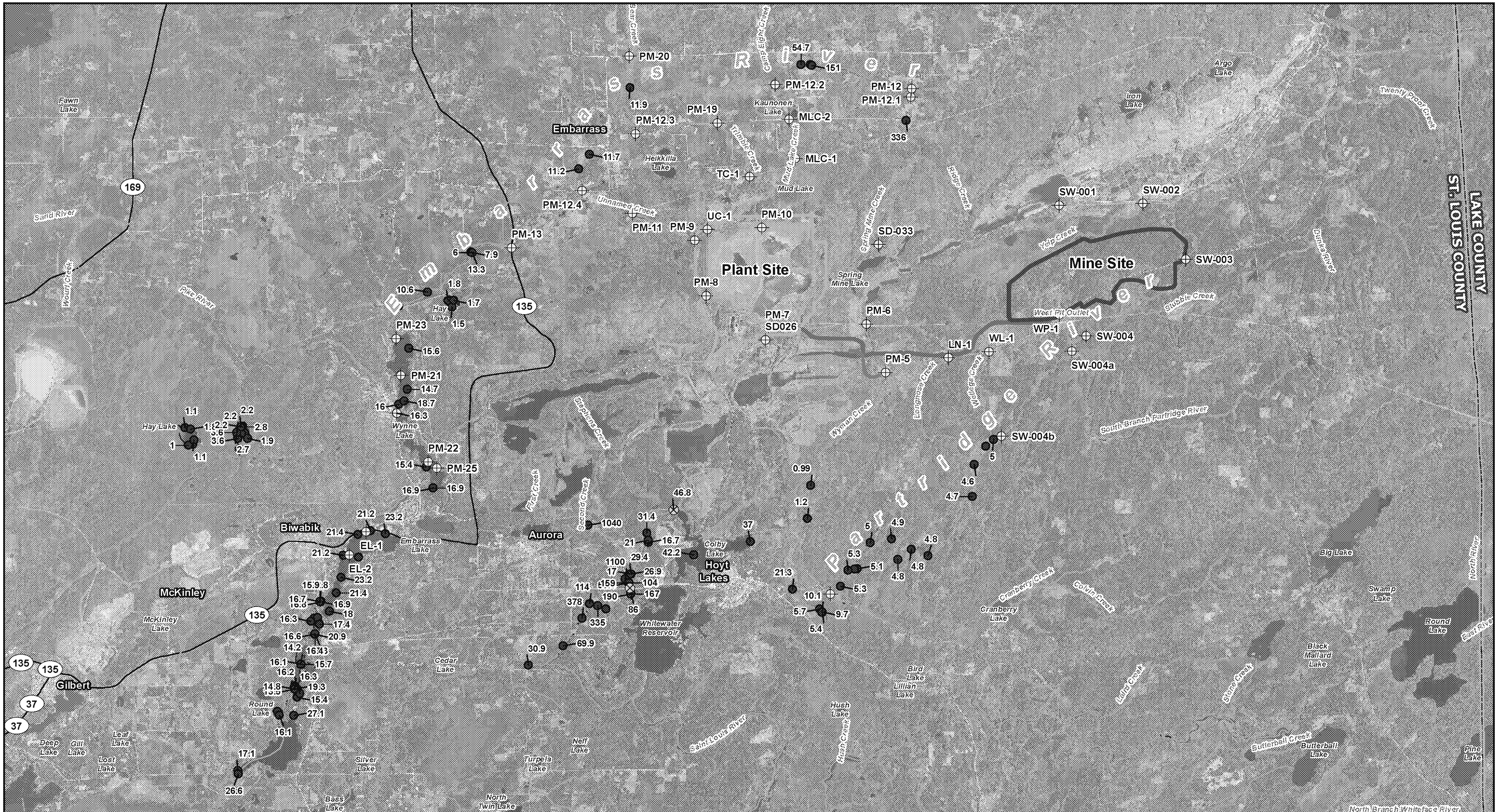
Figure 4.2.2-2

MDNR-Designated Public Waters

NorthMet Mining Project and Land Exchange FEIS

Minnesota

November 2015



Mine Site
Plant Site
Transportation and Utility Corridor
Stream/River
Surface Water Monitoring Station
Mesabi Nugget Surface Water Monitoring Data - Aug. 19, 2009 (values are for sulfate concentration in mg/L)
2009-2013 Wild Rice Surveys Sulfate Sampling Locations with Sulfate Listed in mg/L

MNDNR
US Army Corps of Engineers
St. Paul District

N
W
E
S

0 0.5 1 2 3 4 Miles

Figure 4.2.2-3
Sulfate Sampling Locations
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

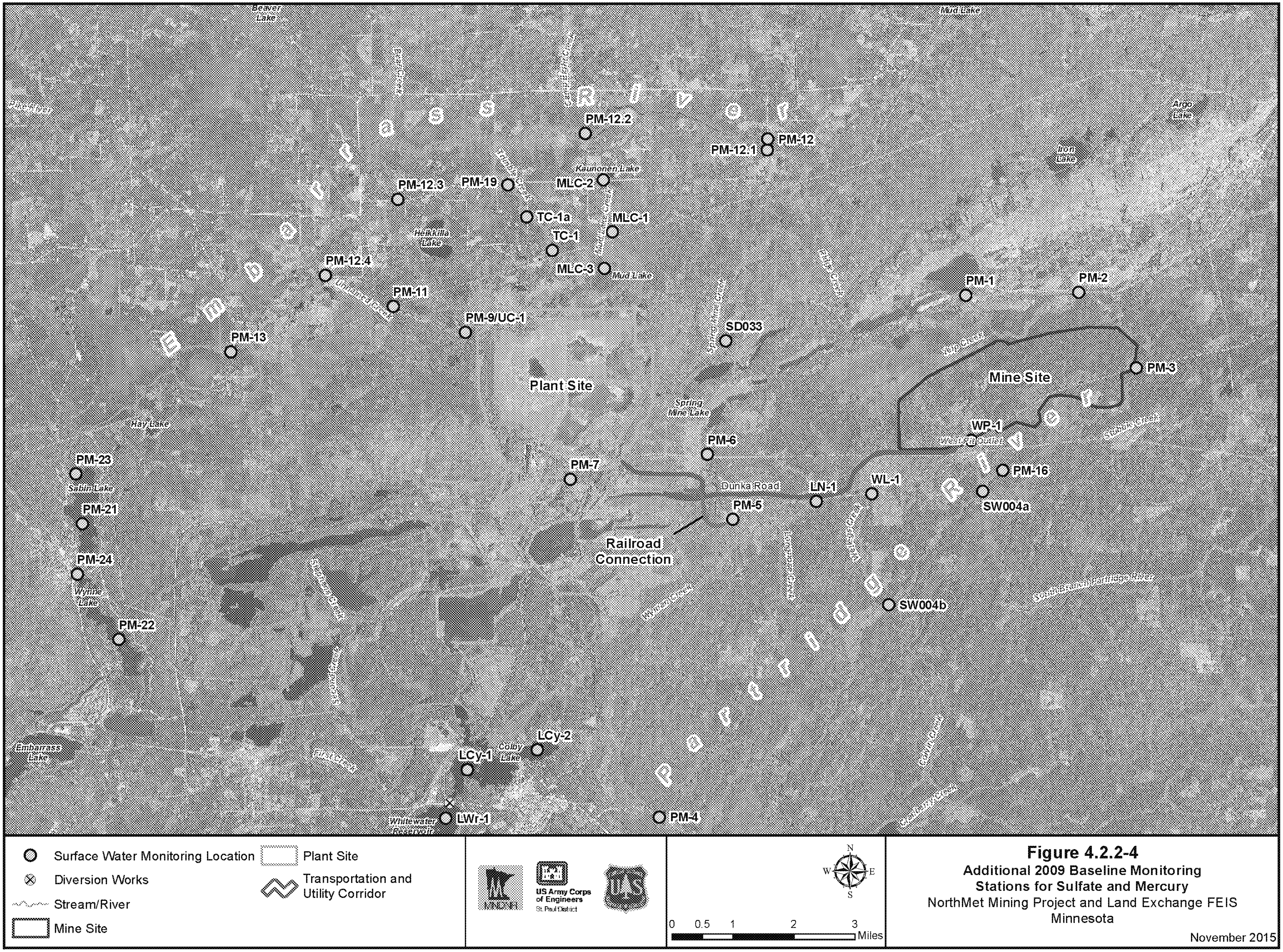


Figure 4.2.2-4
Additional 2009 Baseline Monitoring Stations for Sulfate and Mercury
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

Table 4.2.2-3 Wild Rice Survey and Water Quality Monitoring Results

Locations Surveyed	Survey Year	Wild Rice Found?[1]	Density Factor[2] (Scale 1-5)	Sulfate Range[3] (mg/L)
Partridge River Watershed				
Upper Partridge River (above Colby Lake, portions)	09, 10, 11, 12	Yes (isolated)	1–3	5–21
Colby Lake	09, 10	No	---	37–42
Lower Partridge River (below Colby Lake)	09, 10, 11, 12	Yes	1–5	17–411
Wyman Creek	11, 12	No	---	---
Second Creek (portions)	09, 10, 11, 12	Yes (near mouth)	1–4	1,100
Embarrass River Watershed				
Upper Embarrass River (Spring Mine Creek to Sabin Lake)	09, 10, 11, 12	Yes (isolated)	1	6–151
Sabin - Wynne Lakes	09, 10, 11, 12	Yes (isolated)	1	15–16
Chain of Lakes (including Embarrass, Lower Embarrass, Cedar Island, Esquagama, Unnamed, and Fourth)	09, 10, 11, 12	Yes	1–5	14–27
Lower Embarrass River (Esquagama Lake to CR 95)	09, 10	No	---	---
Spring Mine Creek (portions)	09, 10, 11, 12	No	---	---
Trimble and Unnamed Creeks (portions)	10, 11, 12	No	---	---

Sources: Barr 2010c; Barr 2011a; 2012a; Barr 2013l; Barr 2013p.

Notes:
[1] "Yes" indicates that wild rice was observed in at least one of the survey years. Simply finding wild rice in a survey is not the same as being designated a water used for the production of wild rice.
[2] Informal observational scale of relative wild rice density (1 – low density to 5 – high density)
[3] Range of water column sulfate concentration taken at time of wild rice survey. Samples were only taken when and where wild rice was observed. Values rounded to nearest 1 mg/L. Sample sizes were low resulting in relatively large variability within some individual waterbodies.

Surveys of the St. Louis River from Brookston to Lake Superior were conducted in 2009 and from the NorthMet Project area to the St. Louis Estuary in 2010. Wild rice was identified on the St. Louis River for a short distance downstream from its confluence with the Partridge River. The most dense stand (density factor of 2) was located just upstream of Highway 100, and a few sparse stands were also located approximately 500 and 1,000 ft further downstream (see Figure 4.2.2-3). Sulfate concentrations in 2010 in the St. Louis River near Highway 100 averaged 17.7 mg/L.

4.2.2.1.4 Mercury

Based on sampling done for the NorthMet Project Proposed Action from 2004 to 2013, total mercury concentrations in the Upper Partridge River average about 3.3 ng/L (Barr 2014m). At monitoring station SW-005, total mercury concentrations range from below the analytical detection limit to a maximum of 18.4 ng/L, with an average concentration of 4.3 ng/L. In Colby

Lake, total mercury concentrations are between 4.6 and 8.7 ng/L, averaging 6.0 ng/L. Total mercury concentrations are similar in the Embarrass River, averaging 5.1 ng/L at monitoring station PM-12 and 4.3 ng/L at monitoring station PM-13 from 2004 to 2013 (see Table 4.2.2-4). Methylmercury concentrations in the Partridge River at SW-005 average 0.41 ng/L (see Table 4.2.2-14) and in the Embarrass River average 0.53 ng/L at PM-12 and 0.38 ng/L at PM-13 over the same period (see Table 4.2.2-30). In addition, mercury monitoring has occurred at other locations in and near the existing LTVSMC Tailings Basin (see Table 4.2.2-4 and Figure 4.2.2-4). Generally, total mercury concentrations are consistent with baseline levels, averaging less than 2.0 ng/L. Sample locations in and near the existing LTVSMC Tailings Basin were well below average concentrations in precipitation (approximately 13 ng/L; PolyMet 2015m).

A QA/QC review was conducted to assess the monitoring performance which includes monitoring for mercury. This review was performed in accordance with Barr Engineering Standard Operating Procedure for data validation, which is based on *The National Functional Guidelines for Inorganic and Organic Data Review* (USEPA 2004b and 2005b). Both laboratory and field sampling procedures were examined in the review of the data for the respective sampling events. Field sampling procedures were examined utilizing field blank and equipment blank analysis and blind field duplicate data. Laboratory procedures were evaluated by examining recommended holding times and preservation, laboratory blank analyses, laboratory control samples and laboratory control sample duplicates, duplicate analysis, matrix spikes and matrix spike duplicates, and laboratory duplicate data (PolyMet 2015m; PolyMet 2015j).

Table 4.2.2-4 Summary of Total Mercury Concentrations in the Partridge River and Embarrass River Watersheds near the Mine Site and Plant Site

			Mercury Concentrations		
Location[1]	**Dates**	**# of Detections**	**Mean[2] (ng/L)**	**Range (ng/L)**	**# Exceeding 1.3 ng/L[3]**
Partridge River					
SW-001	2004, 2006, 2008	5 of 10	2.3	<1–<5	5
SW-002	2004, 2006, 2012, 2013	10 of 15	2.7	<2–<5	12
SW-003	2004, 2006–2008, 2012, 2013	19 of 31	2.8	<1–7.8	24
SW-004	2004, 2006–2008, 2010, 2012, 2013	23 of 33	3.3	<0.25–8.7	27
SW-004a	2010, 2012, 2013	11 of 11	4.1	0.79–12.5	8
SW-004b	2010, 2012, 2013	11 of 11	5.4	0.82–18.5	10
SW-005	2004, 2006– 2008, 2010, 2012, 2013	22 of 33	4.3	<0.25–18.4	28
Creeks, Partridge River Watershed					
LN-1	2011–2013	13 of 13	3.5	1.2–9.2	12
WP-1	2011–2013	6 of 6	13.9	5.1–28.1	6
WL-1	2011–2013	12 of 12	5.0	2.1–9.8	12
PM-5	2004, 2011–2013	22 of 27	1.2	<0.25–3.4	9
PM-6	2004, 2013	4 of 5	3.5	<0.25–7.9	3
Lakes (Surface), Partridge River Watershed					
Colby Lake	2008, 2013	9 of 9	6.0	4.6–8.7	9
LTVSMC Tailings Basin Surface Water Seepage					
PM-9	2001–2006	12 of 65	1.8	0.7–4.1	6
PM-10	2001–2007	14 of 66	1.4	0.6–2.3	7
SD-004	2002–2009	23 of 23	1.4	<0.25–4.5	6
SD-005	2001–2004	2 of 18	1.6	1.2–2	1
PM-8	2001–2006	13 of 17	1.7	0.5–4.6	7
WS013	2001–2005	7 of 29	2.1	0.9–6.3	2
Cell 1E	2002–2003	3 of 25	0.2	<0.1–1	0
Cell 2E	2001–2003	3 of 20	0.35	<0.1–3.6	1
Cell 2W	2001	0 of 8	<0.1	NA	0
Emergency Basin	2001–2005	12 of 41	0.7	<0.1–4.2	10
West Seep	2001–2003	1 of 17	0.23	<0.1–<1.25	0
Embarrass River					
PM-13	2004, 2006–2008, 2012, 2013	23 of 35	4.3	<1–12.4	29
PM-12	2004, 2006–2008, 2012, 2013	28 of 34	5.1	<1–<10	33
Creeks, Embarrass River Watershed					
PM-11	2004, 2006, 2008, 2011–2013	24 of 30	2.5	<0.25–<10	19
PM-19	2011–2013	26 of 26	1.5	0.5–5.1	7
PM-20[(4)]	2009	8 of 8	2.5	1.3–4	7
TC-1	2012	1 of 1	1.1	1.1–1.1	0
TC-1A	2012, 2013	4 of 4	2.5	0.9–5.1	2
MLC-1	2011–2013	7 of 7	2.2	1.1–4	6
MLC-2	2011–2013	14 of 14	3.1	0.9–6.5	12
MLC-2/MLC-3A	2012	1 of 1	0.99	0.99–0.99	0

			Mercury Concentrations		
Location[1]	Dates	# of Detections	Mean[2] (ng/L)	Range (ng/L)	# Exceeding 1.3 ng/L[3]
Lakes (surface), Embarrass River Watershed					
PM-23/Sabin Lake	2009	5 of 5	3.19	1.9–4.8	5
PM-21/Sabin Lake	2009	5 of 5	3.26	2.1–5.5	5
PM-22/Wynne Lake	2009	5 of 5	3.12	2–5	5
PM-24/Wynne Lake	2009	5 of 5	3.56	3.2–4.3	5
PM-25	2009	3 of 3	6.47	4.9–8.1	3
Wetlands					
Wetland 003	2002–2005	7 of 12	2.2	<1 to 4.4	7
Wetland North	2002–2005	8 of 11	3.6	<1 to 6.7	8

Sources: Barr 2007h; Barr 2006f; Barr 2009c; Barr 2010c; Barr 2014d.

Notes:
1 See Figures 4.2.2-1, 4.2.2-4, 4.2.2-11, 4.2.2-13, and 4.2.2-15.
2 Where non-detects occur, the mean was calculated using half the detection limit.
3 Minnesota Class 2B Lake Superior standard for mercury.
4 Dissolved mercury concentrations are presented in the table for PM-20, as only dissolved samples were collected and analyzed for this sample location.

The MDNR has additionally conducted numerous research studies regionally and in the St. Louis River watershed specifically. The river and its tributaries frequently have mercury concentrations that exceed the 1.3 ng/L standard, especially in the weeks following major storm events. The vast majority of the mercury carried in the river is bound to dissolved organic carbon that is derived from wetland areas and riparian soils (summarized in Berndt et al. 2014).

4.2.2.2 Partridge River Watershed

This section describes the baseline hydrology and water quality for the groundwater and surface water within the Partridge River Watershed portion of the NorthMet Project area. This includes all of the Mine Site and the Transportation and Utility Corridor, as well as the former LTVSMC processing plant and a small portion of the Tailings Basin.

4.2.2.2.1 Groundwater Resources

This section describes the geology and hydrogeology of the NorthMet Project area and the groundwater resources at the Mine Site that could be affected by the NorthMet Project Proposed Action. Since the publication of the DEIS, additional groundwater monitoring wells were installed and data collected to better describe the groundwater resources at the Mine Site.

In total, 24 monitoring wells were installed in the surficial aquifer and 9 in bedrock (see Figure 4.2.2-8). Six or more groundwater samples have been collected for chemical analysis from each of those wells, except one surficial aquifer well that was dry after the first sampling (so it only provided a single sample) and three bedrock wells that were also sampled once only. A statistical analysis indicated that the total number of groundwater quality samples was sufficient to satisfy the USEPA's request that an uncertainty range around the estimate of average concentration for each solute could be identified such that there was a less than 5 percent probability that the actual average would be outside of this range (Barr 2012p).

This section describes available baseline data on the hydraulic properties of the rocks and sediments at the Mine Site, the rationale for assessing its adequacy, and a summary of specific values for Mine Site baseline aquifer characteristics.

Table 4.2.2-14 Average Existing Water Quality Concentrations in the Partridge River

Parameter	Units	Evaluation Criteria[6]			SW-001	SW-002	SW-003	SW-004	SW-004a	SW-004b	SW-005
			Detection	Range	Mean						
General											
Alkalinity	mg/L		143 of 144	<0–853	94.6	101	83.2	97.3	76.6	59.8	56.5
Calcium	mg/L	--	230 of 230	3.9–45.9	24.6	29.8	22.9	21.1	21.8	16.9	15.3
Chloride	mg/L	230	224 of 224	0.7–55.2	1.6	25.7	10.3	9.2	9.3	5.7	5.7
Fluoride	mg/L	--	59 of 97	<0.05–<2.5	0.14	0.11	0.09	0.10	0.11	0.10	0.30
Hardness	mg/L	500	230 of 230	16.9–228	97.0	141	98.5	92.1	97.8	78.9	71.2
Magnesium	mg/L	--	230 of 230	2.7–29.1	10.4	16.7	10.3	9.7	10.6	8.9	8.1
pH	s.u.	6.5–8.5	218 of 218	5.6–8.73	8.3	7.1	7.4	7.4	7.2	7.2	7.4
Potassium	mg/L	--	84 of 85	<1.25–5.2	2.7	3.0	2.4	2.2	2.5	1.7	1.4
Sodium	mg/L	--	95 of 95	1.2–40.4	4.8	14.5	6.5	6.7	10.2	6.7	4.4
Sulfate	mg/L	10[1]	223 of 230	<0.5–83.1	21.8	30.8	15.1	13.9	15.9	11.3	**10.1**
TDS	mg/L	700	222 of 222	56–395	119	235	161	155	171	153	143
Metals											
Aluminum	µg/L	125	170 of 196	<5–4600	18.0	31.3	51.8	**193**	119	**127**	**129**[4]
Antimony	µg/L	31	0 of 104	<0.25–<1.5	1.5	0.53	0.53	0.53	0.25	0.25	0.53
Arsenic	µg/L	53	96 of 154	<0.25–11.7	6.5	0.48	0.90	1.1	0.95	0.96	1.0
Barium	µg/L	--	44 of 70	<5–36	5.0	17.3	11.3	9.6	12.0	8.9	8.7
Beryllium	µg/L	--	0 of 70	<0.1–<0.1	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Boron	µg/L	500	79 of 95	<17.5–435	96.0	148	94.8	93.0	116	75.9	51.4
Cadmium	µg/L	2.5[2]	6 of 80	<0.01–<0.1	0.10	0.10	0.10	0.09	0.08	0.07	0.09
Cobalt	µg/L	5.0	94 of 212	<0.1–<12.5	0.45	0.30	0.33	0.57	0.42	0.43	1.16
Copper	µg/L	9.3[2]	186 of 222	<0.25–9.1	1.6	0.8	1.0	1.5	1.5	1.5	1.6
Iron	µg/L	--	161 of 163	<15–30700	30.0[5]	3,125[7]	1,570[8]	2,653[9]	2,031	2,402	2,264[10]
Lead	µg/L	3.2[2]	38 of 183	<0.015–12.3	0.30	0.29	0.27	0.32	0.22	0.26	0.41[11]
Manganese	µg/L	--	171 of 173	<5–6480	7.9	254	135	339	170	148	138

Parameter	Units	Evaluation Criteria[6]	Detection	Range	SW-001	SW-002	SW-003	SW-004	SW-004a	SW-004b	SW-005
								Mean			
Mercury	ng/L	1.3	101 of 144	<0.25–18.5	**2.3**	**2.7**	**2.8**	**3.3**	**4.1**	**5.4**	**4.3**
Methylmercury	ng/L	--	39 of 42	<0.028–560	0.05	--	0.27	0.39	0.6[3]	0.51	0.41
Nickel	µg/L	52[2]	152 of 42	<0.000028–0.56	1.4	0.71	1.1	1.5	1.2	1.6	1.7
Selenium	µg/L	5.0	13 of 173	<0.1–<5	1.7	0.90	0.90	0.73	0.44	0.64	0.77
Silver	µg/L	1.0[2]	0 of 95	<0.1–<0.5	0.29	0.21	0.21	0.20	0.10	0.10	0.20
Thallium	µg/L	0.56	75 of 179	<0.0002–<1	**0.60**	0.19	0.19	0.16	0.01	0.01	0.15
Vanadium	µg/L	--	0 of 36	<1.5–<1.5	--	1.5	1.5	1.5	1.5	1.5	1.5
Zinc	µg/L	120[2]	48 of 222	<0–82.9	8.9	5.5	8.7	10.3	4.6	4.2	10.5

Source: Barr 2014d.

Notes:
Values in bold indicates an exceedance of surface water quality standard, based on the average value of all samples. Means calculated using non-detects at half the detection limit.
1 MPCA has listed the Partridge River downstream from river mile approximately 22 just upstream of the railroad bridge near Allen Junction as wild rice water, so the 10 mg/L sulfate standard is only applicable to that portion of the Upper Partridge River (SW-005 and SW-006).
2 Water quality standard for this metal is hardness-dependent. Listed value assumes a hardness concentration of 100 mg/L.
3 Excludes single outlier value of 0.56 µg/L from values included in Barr 2014d.
4 Excludes single outlier value of 1,550 µg/L from values included in Barr 2014d.
5 Excludes single outlier value of 0.06 µg/L from values included in Barr 2014d.
6 Section 5.2.2 includes a detailed discussion of evaluation criteria.
7 Excludes single outlier value of 1.27 µg/L from values included in Barr 2014d.
8 Excludes single outlier value of 1.45 µg/L from values included in Barr 2014d.
9 Excludes single outlier value of 1.41 µg/L from values included in Barr 2014d.
10 Excludes single outlier value of 2.03 µg/L from values included in Barr 2014d.
11 Excludes single outlier value of 12.3 µg/L from values included in Barr 2014d.

Table 4.2.2-15 Mean Water Quality Data for Longnose Creek, Wetlegs Creek, Wyman Creek, and West Pit Outlet Creek

Parameter	Units	Detection	Range	Evaluation Criteria[6] (Longnose, West Pit Outlet and Wetlegs)	Longnose Creek[1] LN-1 Mean	West Pit Outlet Creek[7] WP-1 Mean	Wetlegs Creek[2] WL-1 Mean	Evaluation Criteria[5, 6] (Wyman)	Wyman Creek[3] PM-5 Mean	Wyman Creek[3] PM-6 Mean
General										
Alkalinity	mg/L	61 of 64	<5–200	--	44.3	21.3	39.8	--	157	100
Calcium	mg/L	101 of 101	2.2–51.1	--	11.1	5.7	10.4	--	35.1	23.2
Chloride	mg/L	66 of 101	<0.25–9.9	230	0.63	0.56	1.0	100	1.7	1.0
Fluoride	mg/L	8 of 23	<0.05–0.19	--	0.050	0.050	0.050	(2.0)	0.091	0.13
Hardness	mg/L	98 of 98	11.8–258	500	48.7	28.8	49.5	250	199	107
Magnesium	mg/L	101 of 101	1.5–36.1	--	4.8	3.3	5.5	--	27.7	14.6
pH	s.u.	99 of 99	5.0–8.3	6.5-8.5	6.8	5.7	6.7	6.5–8.5	7.3	7.6
Potassium	mg/L	65 of 67	<0.125–7.0	--	0.63	0.50	0.78	--	5.1	2.1
Sodium	mg/L	52 of 67	<1–17.5	--	1.6	1.3	1.3	--	13.6	6.2
Sulfate	mg/L	74 of 101	<0.5–96.2	--	0.91	2.6	3.9	(250)	67.1	28.1
TDS	mg/L	101 of 101	60.0–352	700	119	152	127	500	270	199
Metals - Total										
Aluminum	µg/L	77 of 95	<10–1,310	125	64.6	**421**	**170**	87	51.8	**102**
Antimony	µg/L	2 of 75	<0.25–<1.5	31	0.25	0.25	0.24	6	0.43	1.5
Arsenic	µg/L	84 of 101	<0.25–6.0	53	1.2	1.9	1.2	2	1.4	0.94
Barium	µg/L	26 of 43	<5–30.6	--	10.4	10.3	10.5	2,000	10.9	10.6
Beryllium	µg/L	0 of 43	<0.1–<0.1	--	0.10	0.10	0.10	4.0	0.10	0.10
Boron	µg/L	12 of 43	<17.5–72.8	500	25.0	25.0	25.0	500	49.5	23.3
Cadmium	µg/L	3 of 43	<0.015–<0.1	2.5[4]	0.070	0.083	0.072	2.5	0.079	0.10
Cobalt	µg/L	60 of 95	<0.1–8.3	5	0.61	1.7	3.7	2.8	0.48	0.50
Copper	µg/L	67 of 95	<0.075–50.9	9.3[4]	0.45	3.6	5.5	9.3[4]	0.68	2.0
Iron	µg/L	101 of 101	237–35,000	--	4,019	7,050	6,372	(300)	1,437	1,872

Parameter	Units	Detection	Range	Evaluation Criteria(6) (Longnose, West Pit Outlet and Wetlegs)	Longnose Creek(1) LN-1	West Pit Outlet Creek(7) WP-1	Wetlegs Creek(2) WL-1	Evaluation Criteria(5, 6) (Wyman)	Wyman Creek(3) PM-5	Wyman Creek(3) PM-6
			v. high			Mean			Mean	
Lead	µg/L	21 of 81	<0.01–3.1	3.2(4)	0.24	1.0	0.37	3.2(4)	0.26	0.50
Manganese	µg/L	98 of 98	15.2–4,920	--	708	358	678	(50)	1058	428
Mercury	ng/L	58 of 64	<0.25–28.1	1.3	**3.5**	**13.9**	**5.0**	1.3	1.2	**3.5**
Nickel	µg/L	50 of 95	<0.25–22.4	52(4)	0.62	6.9	5.3	52(4)	0.57	2.5
Selenium	µg/L	2 of 81	<0.1–<1	5.0	0.43	0.48	0.44	5.0	0.52	1.0
Silver	µg/L	0 of 43	<0.1–<0.5	1.0(4)	0.10	0.10	0.10	0.12	**0.20**	**0.50**
Thallium	µg/L	29 of 90	<0.0002–<1	0.56	0.0079	0.013	0.010	0.28	0.15	**1.0**
Vanadium	µg/L	1 of 33	<1.5–9.3	--	3.1	4.3	2.8	--	3.0	--
Zinc	µg/L	15 of 92	<3–134	120(4)	3.0	6.9	10.5	120(4)	3.6	5.0
			Methylmercury (ng/L)		0.21	0.92	0.48		0.15	ND
			%		6.0	5.9	9.6		12.5	

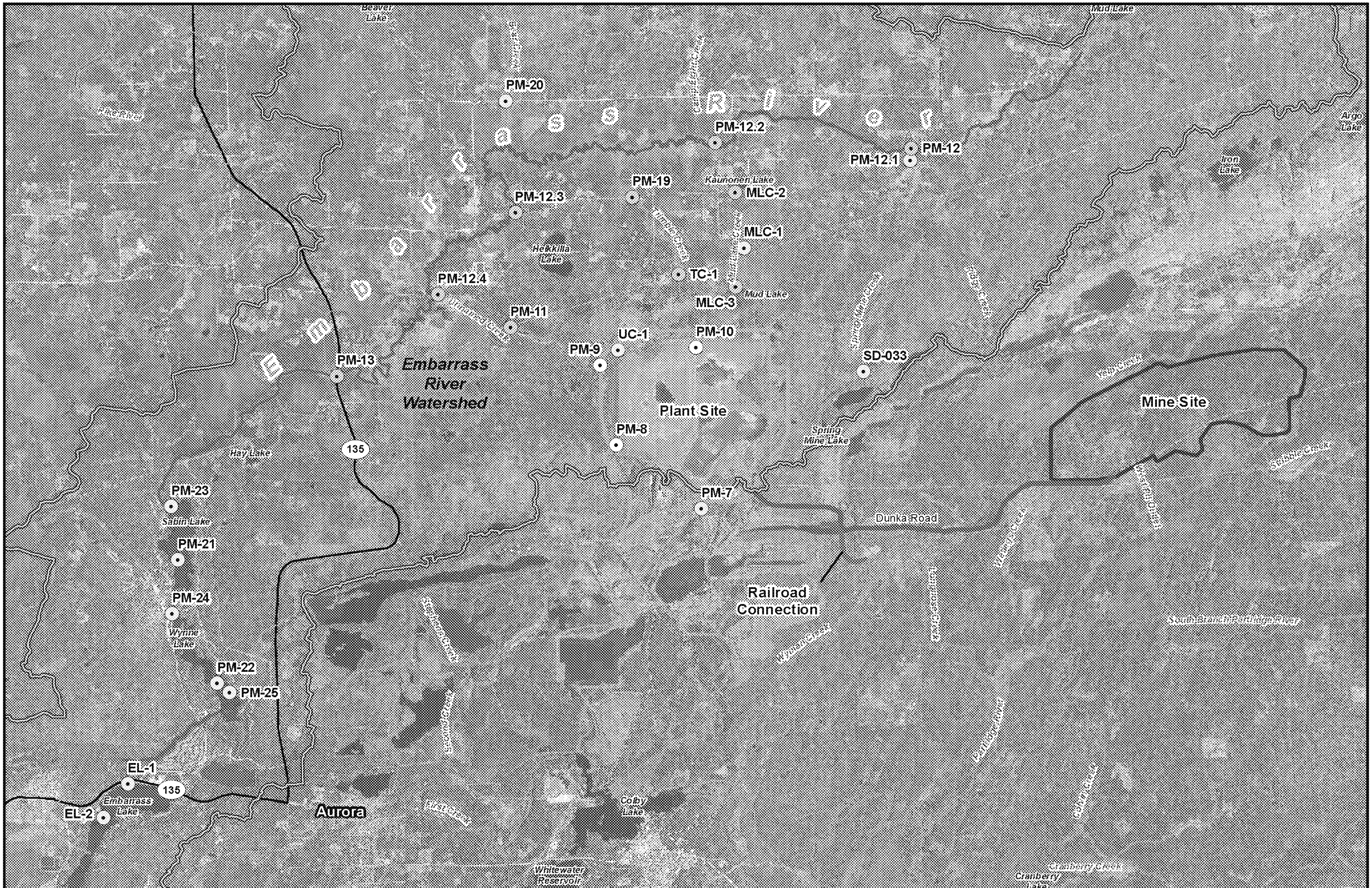
— Barr 2014d

high methylation potential

Source: Barr 2014d.

Notes:
Values in bold indicate an exceedance of surface water quality standard.
1 Based on nine samples collected in 2011, seven samples collected in 2012, and eight samples collected in 2013; Source: Large Table 10, Barr 2014d.
2 Based on eight samples collected in 2011, seven samples collected in 2012, and eight samples collected in 2013; Source: Large Table 10, Barr 2014d.
3 Wyman Creek PM-5 based on four samples collected in 2004, eight samples collected in 2011, nine samples collected in 2012, and 12 samples collected in 2013; PM-6 based on four samples collected in 2004 and one sample collected in 2013.
4 Water quality standard for this metal is hardness-dependent. Listed value assumes a hardness concentration of 100 mg/L.
5 Values in parentheses indicate Secondary Maximum Contaminant Levels (sMCLs).
6 See Section 5.2.2 for a detailed discussion of the evaluation criteria.
7 West Pit Outlet Creek averages based on four samples collected in 2011, four samples collected in 2012, and seven samples collected in 2013.

Not sure why the methylmercury data was not incl. in EIS like it was in other tables.



Mine Site
Plant Site
Transportation and Utility Corridor
Embarrass River
Surface Water Monitoring/Modeling Location
Surface Water Monitoring Location
Embarrass River Watershed
Extisting Road

US Army Corps of Engineers
St. Paul District

N W E S
0 0.5 1 2 3 Miles

Figure 4.2.2-19
Surface Water Monitoring and Modeling Locations within the Embarrass River Watershed
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

Table 4.2.2-32 Average Existing Water Quality in the Embarrass River, 2004-2013[1]

Parameter	Units	Evaluation Criteria	Spring Mine Creek PM-12.1			Embarrass River PM-12			PM-12.2			PM-12.3			PM-12.4			PM-13		
			Detection	Mean	Range	Detection	Mean	Range	Detection	Mean	Range	Detection	Mean	Range	Detection	Mean	Range	Detection	Mean	Range
General																				
Alkalinity	mg/L	--	2 of 2	140	120–159	33 of 33	50.2	15.2–152	--	--	--	--	--	--	--	--	--	31 of 31	90.5	26.0–197
Calcium	mg/L	--	2 of 2	36.3	33.0–39.6	46 of 46	13.8	4.1–29.3	--	--	--	--	--	--	--	--	--	44 of 44	21.7	7.0–44.7
Chloride	mg/L	230	29 of 29	2.5	0.62–4.9	61 of 61	4.7	1.3–22.3	27 of 27	3.4	1.3–10.3	27 of 27	4.7	1.5–11.2	27 of 27	5.0	1.6–13.0	59 of 59	5.8[2]	2.0–94.8
Fluoride	mg/L	--	0 of 0	--	--	11 of 21	0.10	<0.05–0.20	--	--	--	--	--	--	--	--	--	18 of 21	0.37	<0.05–2.3
Hardness	mg/L	500	2 of 2	380	330–429	46 of 46	60.4	17.8–171	--	--	--	--	--	--	--	--	--	44 of 44	129	35.6–337
Magnesium	mg/L	--	2 of 2	70.2	60.2–80.1	46 of 46	6.4	1.9–27.3	--	--	--	--	--	--	--	--	--	44 of 44	18.3	6.1–54.7
pH	s.u.	6.5-8.5	28 of 28	7.5	6.7–**8.6**	61 of 61	6.9	**5.8**–7.9	25 of 25	7.0	**6.1**–8.1	26 of 26	7.2	**6.3**–7.9	26 of 26	7.3	**6.4**–8.2	59 of 59	7.4	**6.3–8.6**
Potassium	mg/L	--	2 of 2	15.3	12.7–17.8	13 of 15	1.1	<0.25–4.0	1 of 1	7.4	7.4–7.4	--	--	--	--	--	--	13 of 13	2.8	1.5–7.4
Sodium	mg/L	--	2 of 2	27.7	23.0–32.4	17 of 17	3.6	2.2–9.0	--	--	--	--	--	--	--	--	--	15 of 15	13.0	5.2–29.8
Sulfate	mg/L	10[4]	29 of 29	388	81.6–944	48 of 65	7.2	<0.5–116	27 of 27	131	30.4–490	27 of 27	50.2	5.6–221	27 of 27	42.8	5.7–181	64 of 64	**39.4**[3]	7.6–**688**[6]
TDS	mg/L	700	2 of 2	521	490–551	46 of 46	130	46.0–258	--	--	--	--	--	--	--	--	--	44 of 44	210	48.0–494
Metals																				
Aluminum	µg/L	125	20 of 23	57.4	<10–**210**	40 of 40	99.8	44.3–**210**	22 of 23	80.2	<10–**174**	23 of 23	**130**	26.8–**433**	22 of 23	122	<12.5–**349**	40 of 40	**188**	43.9–**505**
Antimony	µg/L	31	0 of 1	0.25	<0.25–<0.25	0 of 19	0.51	<0.25–<1.5	--	--	--	--	--	--	--	--	--	0 of 18	0.53	<0.25–<1.5
Arsenic	µg/L	53	0 of 2	0.38	<0.25–<0.5	19 of 25	1.6	<0.25–<5	--	--	--	--	--	--	--	--	--	17 of 23	1.2	<0.25–2.5
Barium	µg/L	--	2 of 2	19.5	18.5–20.4	11 of 15	19.0	<5–55.9	--	--	--	--	--	--	--	--	--	13 of 13	34.7	14.3–57.5
Beryllium	µg/L	--	0 of 2	0.10	<0.1–<0.1	0 of 12	0.10	<0.1–<0.1	--	--	--	--	--	--	--	--	--	0 of 10	0.10	<0.1–<0.1
Boron	µg/L	500	1 of 2	37.7	<25–50.4	0 of 13	24.0	<17.5–<50	--	--	--	--	--	--	--	--	--	3 of 10	32.7	<17.5–68.9
Cadmium	µg/L	2.5[5]	0 of 2	0.055	<0.01–<0.1	1 of 15	0.094	<0.01–<0.1	--	--	--	--	--	--	--	--	--	1 of 13	0.10	<0.1–<0.1
Cobalt	µg/L	5	0 of 2	0.10	<0.1–<0.1	23 of 44	1.0	<0.1–4.1	--	--	--	--	--	--	--	--	--	21 of 42	0.46	<0.1–0.89
Copper	µg/L	9.3[5]	1 of 2	0.61	<0.35–0.86	39 of 46	1.1	<0.25–2.8	--	--	--	--	--	--	--	--	--	40 of 44	1.4	<0.35–<2.5
Iron	µg/L	--	21 of 21	308	172–749	28 of 28	4,151	1.7–11,200	19 of 19	2,183	642–4,450	19 of 19	2,522	999–6,620	19 of 19	2,253	1,020–5,790	26 of 26	2,109	2.1–5,610
Lead	µg/L	3.2[5]	1 of 2	0.15	<0.25–<0.25	4 of 33	0.26	<0.15–<0.5	--	--	--	--	--	--	--	--	--	3 of 31	0.28	<0.15–0.63
Manganese	µg/L	--	21 of 21	225	76.9–669	31 of 31	429	15.0–1,490	19 of 19	627	78.9–1,440	19 of 19	569	43.3–1,660	19 of 19	406	53.7–1,050	28 of 29	279	<0.25–757
Mercury	ng/L	1.3	24 of 30	**--4.8**	--<1.0 to 9.	28 of 34	**5.1**	<1 to <10										23 of 35	**4.3**	**<1 to 12.4**
Methylmercury	ng/L	--	0 of 0	--	--	13 of 13	0.53	0.12–1.3	--	--	--	--	--	--	--	--	--	13 of 13	0.38	0.074–1.1
Nickel	µg/L	52[5]	2 of 2	1.2	0.88–1.4	41 of 46	1.4	<0.25–2.8	--	--	--	--	--	--	--	--	--	37 of 44	1.5	<0.25–2.7
Selenium	µg/L	5	1 of 1	0.10	0.096–0.096	1 of 29	0.87	<0.5–<5	--	--	--	--	--	--	--	--	--	0 of 28	0.76	<0.5–<1.8
Silver	µg/L	1.0[5]	0 of 2	0.10	<0.1–<0.1	0 of 17	0.20	<0.1–<0.5	--	--	--	--	--	--	--	--	--	0 of 15	0.21	<0.1–<0.5
Thallium	µg/L	0.56	0 of 2	0.10	<0.1–<0.1	7 of 28	0.19	<0.0002–<1	--	--	--	--	--	--	--	--	--	6 of 26	0.20	<0.0002–<1
Vanadium	µg/L	--	0 of 0	--	--	0 of 6	1.5	<1.5–<1.5	--	--	--	--	--	--	--	--	--	0 of 6	1.5	<1.5–<1.5
Zinc	µg/L	120[5]	0 of 2	3.0	<3–<3	11 of 46	9.5	<3–104	--	--	--	--	--	--	--	--	--	7 of 44	7.9	<3–51.2

Source: Barr 2014d.

Notes:
Values in bold indicates an exceedance of surface water quality standards.
1 2010 data not collected for all parameters. Includes non-detects at half the detection limit.
2 Excludes 94.8 mg/L value from November 8, 2006.
3 Excludes 688 mg/L value from November 8, 2006.
4 The MPCA staff have previously recommended the waters within and downstream from Embarrass Lake, the northernmost tip of Wynne Lake, and the segment of the Embarrass River from Sabin Lake to the Highway 135 bridge as waters used for the production of wild rice, so the 10 mg/L sulfate standard is only applicable to that portion of the Embarrass River (PM-13).
5 Water quality standard for this metal is hardness-dependent. Listed value assumes a concentration of 100 mg/L.
6 Omitting one anomalously high (688 mg/L) value, the concentration range is 7.6 to 173 mg/L.

4.2.6.3.4 Special Status Fish and Macroinvertebrates

No special status fish or macroinvertebrates are known to occur within the Embarrass River Watershed, although the same potential SGCN, federal, and RFSS special status species described for the Partridge River Watershed would also apply to these areas. Suitable habitat is likely present for the same species discussed in Section 4.2.6.1.4.

No invasive fish or macroinvertebrate species are known to occur within the Embarrass River or its tributaries near the Plant Site.

4.2.6.4 Mercury Concentrations in Fish

As discussed in Section 4.2.2, Section 303(d) of the CWA requires states to publish a list of waters that are not meeting one or more water quality standards. The Partridge River is not listed as an impaired water body for mercury on the 303(d) list; however, fish tissue mercury concentrations in the Partridge River were indicative of an impaired waterbody (See Table 4.2.6-15). Standard sampling practices for mercury advisories in the State of Minnesota are performed in accordance with standard protocols to perform a single sampling event that will generally characterize the overall fish mercury concentrations within a river. Therefore, it should be noted that these data only represent one sampling event and may not be representative of the overall fish tissue mercury concentrations within the Partridge River Watershed.

Most of the St. Louis River is listed for "mercury in fish tissue" impairment. Similarly, the Embarrass River is not on the 303(d) list for mercury; however, several lakes downstream of the NorthMet Project area (within the Chain of Lakes), through which the Embarrass River flows, are listed for "mercury in fish tissue" impairment. It should be noted that portions of the Embarrass River, from the headwaters to Embarrass Lake, are listed on the 303(d) list as impaired for "Fishes Bioassessment," a category not related to mercury. Fish consumption advisories have been issued for "mercury in fish tissue" impaired waters by the MDH to provide site-specific consumption guidance on the quantity and frequency of fish species consumed. For waters not listed on the 303(d) list for "mercury in fish tissue," statewide consumption advisories still apply because these waters have not been tested and it is assumed that fish within these waters could potentially contain mercury in sufficient quantities to warrant a consumption advisory. Table 4.2.2-2 provides a summary of impaired waters within the Embarrass River and Partridge River watersheds.

Table 4.2.6-15 Mercury Concentrations in Fish Species Collected During 2014 MDNR Partridge River Fish Surveys

Sample Size	Scientific Name	Common Name	Mercury (ppm)
6	*Perca flavescens*	Yellow Perch	**0.25**[1]
4	*Catostomus commersonii*	White Sucker	0.16
6	*Sander vitreus*	Walleye	**0.63**[1]
8	*Esox lucius*	Northern Pike	**0.62**[1]

Source: MDNR 2015f.

Note:
Bold values indicate mercury concentrations in fish that are indicative of impaired waters (MPCA 2014).
1 Mercury concentrations above 0.2 ppm indicate an impaired water (MPCA 2014).

The following pages are excerpts from Chapter 5 of the FEIS that contains information on the environmental impact of the project.

The NorthMet Project Proposed Action would have the potential to affect groundwater and surface water hydrology and quality in both the Partridge River and Embarrass River watersheds. These two rivers are both tributaries to the St. Louis River and within the Lake Superior Basin. Water quality modeling performed in support of this FEIS indicates that water treatment systems would be needed indefinitely at the Mine Site and Plant Site. The water models constructed to assess the potential effects from the NorthMet Project Proposed Action were not designed to predict the duration of treatment nor do they capture all the factors that influence the duration of treatment (e.g., potential future regulatory and technological changes). Therefore, the models cannot be used to predict when treatment would end. Actual treatment requirements would be assessed on a recurring basis throughout operations, reclamation, and closure considering influent and effluent water quality and monitoring results.

This FEIS also assesses whether the NorthMet Project Proposed Action discharges would cause or add to an exceedance. This was done by evaluating the two modeling events. The first event (Event A) evaluated: 1) how often the NorthMet Project Proposed Action exceeded an evaluation criterion when the Continuation of Exiting Conditions (CEC) modeling scenario did not, and 2) the magnitude of the exceedance. The second event (Event B) evaluated: 1) how often the NorthMet Project Proposed Action concentrations exceeded CEC concentrations when both concentrations were above the evaluation criterion, and 2) the magnitude of the exceedance. Probabilistic chemical concentrations predicted by GoldSim were compared against water quality evaluation criteria and CEC model results at eight groundwater and eight surface water evaluation locations at the Mine Site, and three groundwater and ten surface water evaluation locations at the Plant Site.

With the proposed engineering controls, the water quality model predicts that the NorthMet Project Proposed Action would not cause any significant water quality impacts because: 1) exceedances of the P90 threshold did not occur, 2) the NorthMet Project Proposed Action concentrations were no higher than concentrations predicted for the Continuation of Existing Conditions scenario, 3) the frequency or magnitude of exceedances for NorthMet Project Proposed Action conditions was within an acceptable range, or 4) the effects were not attributable to NorthMet Project Proposed Action discharges.

The NorthMet Project Proposed Action area is located within the Lake Superior Basin, so it is subject to the Great Lakes Initiative (GLI) mercury water quality standard of 1.3 ng/L. The NorthMet ore and waste rock contain trace amounts of mercury, but mass balance modeling and analog data from other natural lakes and mine pit lakes in northeastern Minnesota suggest that the mercury concentration in the West Pit Lake would stabilize at approximately 0.9 ng/L.

There would also be mercury in the tailings, although about 92 percent of the mercury in the ore is predicted to remain in the ore concentrate and the mercury concentration in seepage from the Tailings Basin is expected to be less than the standard. The WWTF and the WWTP would be designed to meet water quality based effluent limits that are protective of the GLI 1.3 ng/L mercury standard. Overall, the NorthMet Project Proposed Action is predicted to increase mercury loadings in the Embarrass River. Mercury loadings in the Partridge River would decrease. The net effect of these changes would be an overall reduction in mercury loadings to the downstream St. Louis River upstream of the Fond du Lac Reservation boundary. Therefore, the NorthMet Project Proposed Action would not add to any potential exceedance of the Fond du Lac mercury water quality standard of 0.77 ng/L within the Reservation.

Mercury was not included in the GoldSim model for either the Mine Site or the Plant Site, as insufficient data and unique modeling requirements for mercury dynamics prevented modeling mercury like the other solutes. Regardless, the NorthMet Project Proposed Action would still need to demonstrate that the mercury evaluation criteria would be protected (see Section 5.2.2.1). Therefore, a simple mass balance model estimation method was used. This simple estimation method was preferred over a detailed mechanistic model because it incorporated the important input and removal processes for mercury, was very transparent with regard to data inputs, and allowed for easy assessment of the effects of changing parameter values on mercury concentrations. For the Mine Site, this method, in combination with analog data from existing natural and mine pit lakes in the region, was used to assess future mercury concentrations in the West Pit lake and in the overflow water. Mercury air emissions and subsequent mercury deposition were not assessed for the Mine Site because potential emissions are less than 1.0 lb/yr (PolyMet 2015e). Information pertaining to mercury deposition is discussed in Section 5.2.7.2.5. The NorthMet Project Proposed Action is also estimated to result in a net decrease in mercury loadings to the Partridge River (see Sections 5.2.2.3.4 and 6.2.2.4).

Table 5.2.2-2 Groundwater Evaluation Criteria Applicable to the NorthMet Project Proposed Action

Solute	Units	USEPA pMCL	MDH HRL	USEPA sMCL	FEIS Evaluation Criteria
General Parameters					
Alkalinity	mg/L	--	--	--	--
Calcium	mg/L	--	--		
Chloride	mg/L	--	--	250	250
Fluoride	mg/L	4	--	2	2
Hardness	mg/L	--	--	--	--
Magnesium	mg/L	--	--	--	--
Potassium	mg/L	--	--	--	--
Sodium	mg/L	--	--	--	--
Sulfate	mg/L	--	--	250	250
Total Dissolved Solids	mg/L	--	--	500	500
Metals					
Aluminum	µg/L	--	--	50-200(4)	--4
Antimony	µg/L	6	6	--	6
Arsenic	µg/L	10	--	--	10
Barium	µg/L	2,000	2,000	--	2,000
Beryllium	µg/L	4	0.08	--	0.39/0.2/0.54(1)
Boron	µg/L	--	1,000(2)	--	1,000
Cadmium	µg/L	5	4	--	4
Chromium[6] III	µg/L	100	--	--	100
Cobalt	µg/L	--	--	--	--
Copper	µg/L	--3	--	1,000	1,000
Iron	µg/L	--	--	300(4)	--4
Lead	µg/L	--3	--	--	--
Manganese	µg/L	--	100	50	1,002/307/704(1)
Nickel (soluble salts)[5]	µg/L	--	100	--	100
Selenium	µg/L	50	30	--	30
Silver	µg/L	--	30	100	30
Thallium (salts)[5]	µg/L	2	0.6	--	0.6/1.0(1)
Vanadium	µg/L	--	50	--	50
Zinc	µg/L	--	2,000	5,000	2,000

Source: pMCLs (40 CFR 141), sMCLs (40 CFR 143), and HRLs (*Minnesota Rules*, part 4717.7500).

Notes:

1 Beryllium, manganese, and thallium (Mine Site bedrock unit only). Evaluation criteria differ by location (Mine Site Surficial Aquifer/Bedrock Aquifer/Plant Site Surficial Aquifer) based on background water quality (see Table 5.2.2-1). Criteria are based on dissolved concentrations unless otherwise noted (MPCA 2014g).

2 See MDH guidance: www.health.state.mn.us/divs/eh/risk/guidance/gw/boron.html.

3 Lead and copper enter drinking water primarily through plumbing materials. In 1991, the USEPA published the Lead and Copper Rule (USEPA 1991). This rule requires water systems to monitor drinking water at customer taps. The 1,300µg/L copper concentration and 15µg/L lead concentration represent action levels that, when exceeded at 10 percent of customer taps, require the water system to take additional actions to control corrosion. Therefore, these values reflect concentrations at the customer tap. Additionally, *Minnesota Rules*, part 7050.0221, subpart 1B, states that the primary drinking water standards for copper and lead are not applicable to Class 1 groundwater.

4 Aluminum and iron were excluded from groundwater evaluation criteria due to baseline USEPA sMCL standard exceedances in the Iron Range and Northeast Minnesota and because these concentrations are heavily influenced by processes not captured in the proposed models (e.g., site-specific redox reactions). Further, standards for these parameters were established for management of aesthetic conditions in treated drinking water and are readily removed from groundwater with simple readily

available treatment technologies. This policy was adopted by the Co-lead Agencies in the NorthMet EIS Groundwater Impact Assessment Planning Final Summary Memo (June 27, 2011) (MDNR et al. 2011).

[5] Nickel and thallium. The MDH HRL is based on the salt form of this parameter. It is conservatively assumed, for purposes of this FEIS, that the salt form is equivalent to the total concentrations of this parameter.

[6] Chromium III is used in this FEIS because it is the most likely form of chromium to be present at NorthMet Project Proposed Action project site.

These groundwater quality evaluation criteria are assessed at the following evaluation locations (see Figures 5.2.2-7 and 5.2.2-9):

- Partridge River Watershed:
  - Surficial Aquifer
    - East Pit and Category 2/3 Flowpath – at the Partridge River (coinciding with property boundary)
    - Ore Surge Pile Flowpath – at the Partridge River
    - WWTF Flowpath – at the property boundary
    - Overburden Storage and Laydown Area Flowpath – at the old property boundary (a short distance south of Dunka Road) which is this FEIS Mine Site boundary
    - West Pit Flowpath – at the property boundary
  - Bedrock
    - East Pit Bedrock Flowpath – at the property boundary
    - West Pit Bedrock Flowpath toward SW-004 – at the property boundary
    - West Pit Bedrock Flowpath toward SW-004a – at the property boundary
- Embarrass River Watershed (all surficial aquifer, see Section 5.2.2.2.3):
  - North Flowpath – at the north property boundary
  - Northwest Flowpath – at the northwest property boundary
  - West Flowpath – at the west property boundary

5.2.2.1.2 Surface Waters

This section discusses evaluation criteria for the effects of the NorthMet Project Proposed Action on surface water hydrology and quality.

Hydrologic Alteration of Streams and Lakes Evaluation Criteria

Hydrologic evaluation criteria include a comparison of proposed hydrologic changes with both existing natural conditions and historic hydrologic alterations from permitted mining practices, an assessment of present and predicted channel stability, and review of any appropriate physical or biological stream data. Evaluation criteria for streamflows in the Partridge River Watershed and changes in lake or reservoir levels in the NorthMet Project Proposed Action area are those developed by (Richter et al.1996; 1998) related to alteration of hydrology and were adopted by the Co-lead Agencies during the IAP process (MDNR et al. 2011b).

The main parameters recommended for this "range of variability" approach include:

- Annual mean daily flow by month;
- Annual maximum 1-day, 3-day, 7-day, 30-day, and 90-day flows;
- Annual minimum 1-day, 3-day, 7-day, 30-day, and 90-day flows;
- Number of high pulses (i.e., the number of times per year the mean daily flow increases above the 75th percentile of all simulated mean daily flows);
- Number of low pulses (i.e., the number of times per year the mean daily flow falls below the 25th percentile of all simulated mean daily flows);
- Duration of high pulses (i.e., the number of days per year with mean flows above the 75th percentile of all simulated daily mean flows);
- Duration of low pulses (i.e., the number of days per year with mean flows below the 25th percentile of all simulated daily mean flows);
- Mean duration of high pulses (i.e., the ratio of duration of high pulses to number of high pulses);
- Mean duration of low pulses (i.e., the ratio of duration of low pulses to number of low pulses); and
- Annual mean, annual maximum, and annual minimum lake levels in Colby Lake and Whitewater Reservoir.

The magnitude of deviation from existing conditions in the hydrologic parameters, based on XP-SWMM modeling prepared for the Partridge River Watershed, helps determine the degree of potential effect on stream ecology. These values are not expressed as compliance standards, but would assist in monitoring effects and recommending potential mitigation measures as appropriate.

Flow characteristics for different reaches of the Embarrass River and selected tributaries were estimated by extrapolating flows from USGS gaging station 04017000 (located just downstream of PM-12.3) on a catchment area basis. Flow parameters estimated in the Embarrass River Watershed include groundwater baseflow, annual 1-day minimum flow, annual 1-day maximum flow, and annual daily mean flow.

The MDNR also has recommended maintaining surface flows within plus or minus 20 percent of existing conditions in NorthMet Project Proposed Action-affected streams to maintain existing aquatic ecology (Chisholm 2006). See section 5.2.6 for more details.

Water Quality Evaluation Criteria

This FEIS assesses effects on water by comparing the predicted water quality under the NorthMet Project Proposed Action against evaluation criteria based on the State of Minnesota water quality standards and use classifications (*Minnesota Rules*, chapters 7050 and 7052). Applicable use classifications of the primary surface waters potentially affected by the NorthMet Project Proposed Action are described in Section 4.2.2 and are summarized in Table 5.2.2-3.

Table 5.2.2-3 Applicable Use Classifications of the Primary Surface Waters in the NorthMet Project Proposed Action Area

		Domestic Consumption	Aquatic Life and Recreation			Industrial Consumption		Agriculture and Wildlife		Aesthetic Enjoyment	Other uses
Watershed	**Stream Name**	**1B**	**2A**	**2B**	**2Bd**	**3B**	**3C**	**4A**	**4B**	**5**	**6**
Partridge	Partridge River			X			X	X	X	X	X
Partridge	West Pit Outlet Creek			X			X	X	X	X	X[1]
Partridge	Wetlegs Creek			X			X	X	X	X	X
Partridge	Longnose Creek			X			X	X	X	X	X
Partridge	Wyman Creek	X	X			X	X	X	X	X	X
Partridge	Colby Lake	X			X		X	X	X	X	X
Embarrass	Embarrass River			X			X	X	X	X	X
Embarrass	Trimble Creek			X			X	X	X	X	X
Embarrass	Mud Lake Creek			X			X	X	X	X	X
Embarrass	Second Creek			X			X	X	X	X	X
Embarrass	Unnamed Creek			X			X	X	X	X	X

Note:
1 The WWTF would discharge to the West Pit Outlet Creek.

In *Minnesota Rules*, part 7050.0221, the USEPA primary and secondary drinking water standards are adopted for Class 1B waters (i.e., those treated with simple chlorination for domestic consumption). The USEPA primary drinking water standards (40 CFR 141) set mandatory MCLs for drinking water contaminants to protect the public from consuming water that presents a risk to human health. The USEPA has also established secondary drinking water standards (40 CFR 143) for 15 contaminants that are intended to assist public water systems in managing their drinking water for aesthetic considerations such as taste, color, and odor. These contaminants are not considered a risk to human health.

The same suite of solutes was modeled for surface waters as described above for groundwater. As mentioned above, hardness and TDS concentrations were not directly modeled.

Because the NorthMet Project Proposed Action area is located in the Lake Superior Basin, the GLI (Lake Superior) water quality standards also apply (*Minnesota Rules*, chapter 7052). These Lake Superior standards can differ from the water quality standards for the same parameters in *Minnesota Rules*, chapter 7050. Where different, the 7052 standards supersede the 7050 standards, even if the 7052 rules are less stringent. For parameters not listed in chapter 7052, the standards from chapter 7050 apply.

Surface water standards are "in-stream" standards applicable at the surface water in question, which include the Partridge River and its tributaries for the Mine Site, Transportation and Utility Corridor, and the Plant Site, and the Embarrass River and its tributaries for the majority of the Tailings Basin.

Applicable surface water quality evaluation criteria, for the purposes of this FEIS, are listed by use classification in Table 5.2.2-4, with the strictest (i.e., lowest) concentration from the applicable water use classifications applying.

It should be noted that the water quality standards for metals are expressed for total metals in the table, but are applied as dissolved metal criteria for application to surface waters (*Minnesota Rules*, part 7050.0220). For the majority of metals, the ratio of the total metal criteria to the dissolved metal criteria is sufficiently close to one such that the total standard is adequately representative of the applicable criteria.

Table 5.2.2-4 Surface Water Quality Evaluation Criteria Applicable to Different Classes of Surface Water

Parameter	Units	Class 1B pMCL	Class 1B sMCL	Class 2A	Class 2Bd[3]	Class 2B[3]	Class 3B[4]	Class 3C[4]	Class 4A[5]	Class 4B[5]	Class 5	Class 6
General												
Alkalinity	mg/L	--	--	--	--	--	--	--	--	--	--	--
Calcium	mg/L	--	--	--	--	--	--	--	--	--	--	--
Chloride	mg/L	--	250	230	230	230	100	250	--	--	--	--
Fluoride	mg/L	4	2	--	--	--	--	--	--	--	--	--
Hardness	mg/L	--	--	--	--	--	250	500	--	--	--	--
Magnesium	mg/L	--	--	--	--	--	--	--	--	--	--	--
pH	s.u.	--	6.5–8.5	6.5–8.5	6.5–9.0	6.5–9.0	6.0–9.0	6.0–9.0	6.0–8.5	6.0–9.0	6.0–9.0	--
Potassium	mg/L	--	--	--	--	--	--	--	--	--	--	--
Sodium	mg/L	--	--	--	--	--	--	--	--	--	--	--
Sulfate	mg/L	--	250	--	--	--	--	--	10[(2)]	--	--	--
TDS	mg/L	--	500	--	--	--	--	--	700	--	--	--
Metals Total[7]							--	--	--	--	--	--
Aluminum	µg/L	--	50–200	87	125	125	--	--	--	--	--	--
Antimony	µg/L	6	--	5.5	5.5	31	--	--	--	--	--	--
Arsenic	µg/L	10	--	2.0[(1)]	2.0[(1)]	53[(1)]	--	--	--	--	--	--
Barium	µg/L	2,000	--	--	--	--	--	--	--	--	--	--
Beryllium	µg/L	4.0	--	--	--	--	--	--	--	--	--	--
Boron	µg/L	--	--	--	--	--	--	--	500	--	--	--
Cadmium[6]	µg/L	5	--	2.5[(1)]	2.5[(1)]	2.5[(1)]	--	--	--	--	--	--
Chromium (III)[6]	µg/L	100	--	86[(1)]	86[(1)]	86[(1)]	--	--	--	--	--	--
Cobalt	µg/L	--	--	2.8	2.8	5.0	--	--	--	--	--	--
Copper[6]	µg/L	--[8]	1,000	9.3[(1)]	9.3[(1)]	9.3[(1)]	--	--	--	--	--	--
Iron	µg/L	--	300	--	--	--	--	--	--	--	--	--
Lead[6]	µg/L	--[8]	--	3.2	3.2	3.2	--	--	--	--	--	--
Manganese	µg/L	--	50	--	--	--	--	--	--	--	--	--
Mercury	ng/L	2,000	--	1.3[(1)]	1.3[(1)]	1.3[(1)]	--	--	--	--	--	--
Nickel[6]	µg/L	--	--	52[(1)]	52[(1)]	52[(1)]	--	--	--	--	--	--
Selenium	µg/L	50	--	5.0[(1)]	5.0[(1)]	5.0[(1)]	--	--	--	--	--	--
Silver	µg/L	--	100	0.12	1.0	1.0	--	--	--	--	--	--
Thallium	µg/L	2	--	0.28	0.28	0.56	--	--	--	--	--	--
Vanadium	µg/L	--	--	--	--	--	--	--	--	--	--	--
Zinc[6]	µg/L	--	5,000	120[(1)]	120[(1)]	120[(1)]	--	--	--	--	--	--

Source: *Minnesota Rules*, chapters 7050 and 7052; USEPA pMCL (40 CFR 141); sMCL (40 CFR 143).

Notes:
All values represent total concentration unless otherwise noted.
[1] Based on *Minnesota Rules*, part 7052.0100, *Water Quality Standards Applicable to Lake Superior Basin*, which supersedes standards listed in *Minnesota Rules*, part 7050.0140.
[2] The quality of Class 4A waters of the state shall be such as to permit their use for irrigation without significant damage or adverse effects upon any crops or vegetation usually grown in the waters or area… The following standards shall be used as a guide in determining the suitability of the waters for such uses… Sulfates (SO_4) - 10 mg/L, applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels.
[3] *Minnesota Rules*, parts 7050.0222 and 7052.0100.
[4] *Minnesota Rules*, part 7050.0223.
[5] *Minnesota Rules*, part 7050.0224.
[6] Water quality standard for this metal is hardness dependent. The listed value assumes a hardness of 100 mg/L.
[7] Standards for metals are expressed as total metals, but must be implemented as dissolved metal standards. Factors for converting total to dissolved metals are listed in *Minnesota Rules*, parts 7050.0222 and 7052.0360.
[8] Lead and copper enter drinking water primarily through plumbing materials. In 1991, USEPA published the Lead and Copper Rule (http://www.epa.gov/safewater/lcrmr/index.html). This rule requires water systems to monitor drinking water at customer taps. The 1,300-µg/L copper concentration and 15-µg/L lead concentration represent action levels that, when exceeded at 10 percent of customer taps, require the water system to take additional actions to control corrosion. Therefore, these values reflect concentrations at the customer tap. Additionally, *Minnesota Rules*, part 7050.0221, subpart 1B, states that the primary drinking water standards for copper and lead are not applicable to Class 1 surface waters.

Surface Water Quality Evaluation Locations

These surface water evaluation criteria are assessed at the following surface water evaluation locations (see Figures 5.2.2-28 and 5.2.2-13):

- Partridge River Watershed
  - Partridge River – at SW-002, SW-003, SW-004, SW-004a, SW-004b, SW-005, and SW-006; and
  - Colby Lake.
- Embarrass River Watershed
  - Embarrass River – at PM-12, PM-12.2, PM-12.3, PM-12.4, and PM-13 (note that model results for evaluation locations PM-12.3 and PM-12.4 did not show anything different so are not discussed further in this FEIS);
  - Mud Lake Creek – at MLC-2 and MLC-3;
  - Trimble Creek – at TC-1 and PM-19; and
  - Unnamed Creek – at PM-11.

Relationship of Hardness to Evaluation Locations

There are six metals evaluated whose surface water quality standards vary with hardness concentrations: cadmium, chromium III, copper, lead, nickel, and zinc. Calcium and magnesium ions that contribute to water hardness generally lower metals toxicity (i.e., as hardness concentration increases, the water quality standard for these metals also increases). In the case of this FEIS, as hardness increases, evaluation criteria increase simultaneously. Within the water quality modeling, estimated concentrations for these six metals are compared to NorthMet Project Proposed Action hardness-based evaluation criteria at each model evaluation location and each model time step to determine the frequency and magnitude of evaluation criteria exceedances. See Section 5.2.2.2.3 for more information.

Downstream Water Quality Standards

The Fond du Lac Band has promulgated water quality standards that are protective of specific, designated, or beneficial uses for waterbodies on the Fond du Lac Reservation. This Reservation is located approximately 70 miles downstream of the NorthMet Project Proposed Action area on the St. Louis River. These standards were approved by the USEPA in December 2001. They apply to all waters, including wetlands, within the Reservation. The Fond du Lac water quality standards include determination of designated or beneficial uses, narrative and numeric criteria to support or sustain those uses, and anti-degradation provisions. This FEIS analyzes compliance with their mercury standard.

Based upon results of Fond du Lac Band water quality monitoring, as well as additional resource investigations, the Reservation's reach of the St. Louis River is attaining all of its beneficial uses and meeting all applicable water quality standards with the exception of mercury. In-stream mercury concentrations in the St. Louis River, measured by the Fond du Lac Band, have been below the GLI Chronic Wildlife Standard of 1.3 ng/L, but exceed the Fond du Lac Band's human health chronic standard of 0.77 ng/L. For this reason, the Fond du Lac Band is especially concerned about any new or expanded discharges to the St. Louis River upstream of the Reservation that may adversely affect mercury bioaccumulation in fish in the St. Louis River (Fond du Lac, Pers. Comm., March 6, 2012).

The MDNR conducted studies in the St. Louis River in 2012, which included an unusually wet spring and early summer followed by a long dry period (Berndt et al. 2014). The studies found that mercury concentrations in filtered samples collected in Cloquet were 3.5 ng/L in May, increased to 7 ng/L in July, and then fell gradually through the rest of the summer to 1.4 ng/L by late October. Upstream from the Partridge River, mercury concentrations over the same period ranged from 5.2 ng/L up to a peak of 11.8 ng/L in late June, eventually decreasing only to 2.3 ng/L by late October when the study ended. Thus, mercury was never below the 1.3 ng/L standard during these study periods. These results indicate the importance of considering seasonal variability when evaluating mercury concentrations in rivers.

Mercury Evaluation Criteria

Mercury numeric standards are based on total (particulate plus dissolved) concentrations. For the Lake Superior Basin, which is where the NorthMet Project Proposed Action is located, the Class 2B (aquatic life and recreation) numeric chronic standard for mercury in the water column protective of wildlife is 1.3 ng/L. This is the evaluation criteria used and is consistent with the GLI standard. The criterion is applied at in-stream surface water evaluation locations and to modeled WWTF and WWTP effluent. This FEIS also considers the 0.77 ng/L standard at the Fond du Lac Reservation. Mercury was not included in GoldSim modeling and was evaluated separately. There is a relationship, only partially understood, between sulfate concentration and the conversion of inorganic mercury by sulfate-reducing bacteria into methylmercury. The MDNR has been conducting numerous studies in the region that indicate a strong contextual component is needed when considering impacts of sulfate on methylmercury production and transport (Berndt et al. 2014). When, how, and where the sulfate is added to a stream or watershed must be considered to evaluate impacts to the mercury cycle.

Methylmercury is more bioavailable than inorganic mercury, and it can bioaccumulate in the aquatic food chain (e.g., fish, wildlife, and humans) to concentrations of concern. Currently, there is no State of Minnesota surface water quality standard for methylmercury, or for sulfate in the context of its potential for effect on methylmercury concentrations, as the production of methylmercury is not only dependent on sulfate concentrations, but also on environmental conditions required for sulfate-reducing bacteria to live (e.g., sufficient organic carbon and lack of oxygen). However, the State of Minnesota has a fish tissue water quality standard for mercury of 0.2 milligram per kilogram (mg/kg), which was amended in *Minnesota Rules*, chapter 7050, in 2008. In 2006, the MPCA also developed a *Strategy to Address Indirect Effects of Elevated Sulfate on Methylmercury Production and Phosphorus Availability*, which identifies policies and review procedures for evaluating the potential of proposed projects to produce methylmercury. This strategy includes recommendations to avoid or minimize the discharge of water with elevated sulfate concentrations to methylmercury "high-risk" situations (MPCA 2006a).

The *Minnesota Rules* fish tissue standard for mercury of 0.2 mg/kg is lower than the USEPA criterion of 0.3 mg/kg (wet weight, per USEPA criteria) to adjust for the higher per capita consumption of wild-caught fish in Minnesota. Methylmercury is the only form of mercury that accumulates appreciably in fish. This criterion reflects this fact by assuming that all fish tissue mercury is in the methylmercury form.

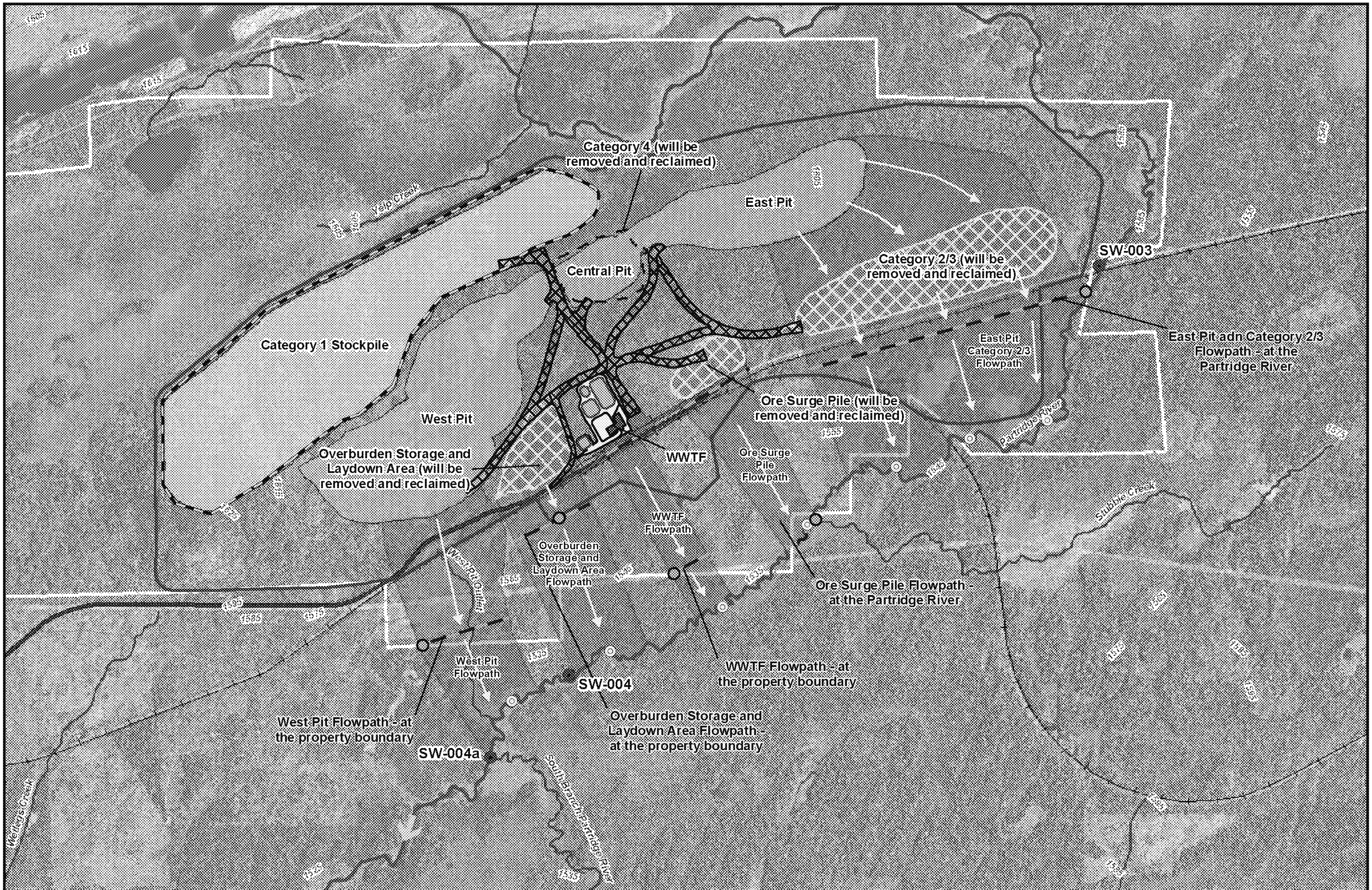
Research suggests that total mercury concentrations in streams and methylmercury content in fish are roughly proportional within individual watersheds (USGS 2010), such that an increase in total mercury in water would be expected to result in an increase in mercury content in fish within that watershed. MPCA's Mercury Risk Estimation Method (MMREM) was used to assess the potential changes in fish mercury concentrations in nearby lakes (Barr 2015f). The MMREM relies on empirical fish contamination data combined with the principle of proportionality between mercury in fish and atmospheric deposition (MPCA 2006c). The potential incremental change in fish mercury concentration is discussed further in Section 6.2.6.3.3.

Waters Used for Production of Wild Rice Evaluation Criteria

Minnesota Rules, part 7050.0224, defines the Class 4A water quality standards for the Agriculture and Wildlife Use Classification, which includes a 10 mg/L sulfate standard "applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels." Application of this standard is therefore dependent on the identification of specific waters used for production of wild rice. When evaluating any facility or project with potential effects on wild rice production, the MPCA considers all available information to determine on a case-by-case basis which surface waters are used for production of wild rice (MPCA 2012b). For the NorthMet Project Proposed Action, the MPCA considered available lists of wild rice beds not promulgated by rule assembled by the MDNR, the 1854 Treaty Authority and the Wild Rice Management Workgroup (a coalition of federal, state, and tribal resource managers and other wild rice stakeholders), and the results off site-specific wild rice field surveys conducted in 2009, 2010, and 2011 in the Partridge and Embarrass rivers. To date within the NorthMet Project Proposed Action area, MPCA (2012b) has reached a draft staff recommendation that the following are waters used for production of wild rice (see Figure 5.2.2-1):

- Within the Embarrass River Watershed:
  - That segment of the Embarrass River from MN Highway 135 bridge to the inlet to Sabin Lake;
  - The northernmost tip of Wynne Lake (Embarrass River inlet); and
  - Embarrass Lake north of the railroad crossing.
- Within the Partridge River Watershed:
  - That portion of Upper Partridge River from river mile approximately 22, just upstream of the railroad bridge near Allen Junction, to the inlet to Colby Lake;
  - That portion of Lower Partridge River from the outlet of Colby Lake to its confluence with the St. Louis River; and
  - That portion of Second Creek from First Creek to the confluence with Partridge River.

Since the development of the draft MPCA staff recommendations, the MPCA has conducted preliminary evaluations of data collected as part of its legislatively mandated wild rice study and has identified conceptual approaches to revising both the numeric sulfate water quality standard of 10 mg/L and the identification of what waters would be subject to any revised standard (wild rice waters). These conceptual approaches will continue to evolve, eventually resulting in a proposed rule. The proposed rule will likely evolve during the rulemaking process as well.



Surficial Aquifer Head Contour (m) at Closure
Groundwater Flowpath
Surface Water Evaluation Location
Groundwater Contacts Surface Water
Groundwater Evaluation Locations
Extent of Future PolyMet Lands
Groundwater Containment System
Permanent Stockpiles
Removed and Reclaimed Stockpile
Removed Stockpile
Surface Water Flow
Mine Site
Haul Road
Mine Pit
Groundwater Flow
Dunka Road
Stream/River

US Army Corps of Engineers
St. Paul District

0 1,000 2,000 4,000 Feet

Figure 5.2.2-7
Mine Site Surficial Groundwater Flowpaths
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

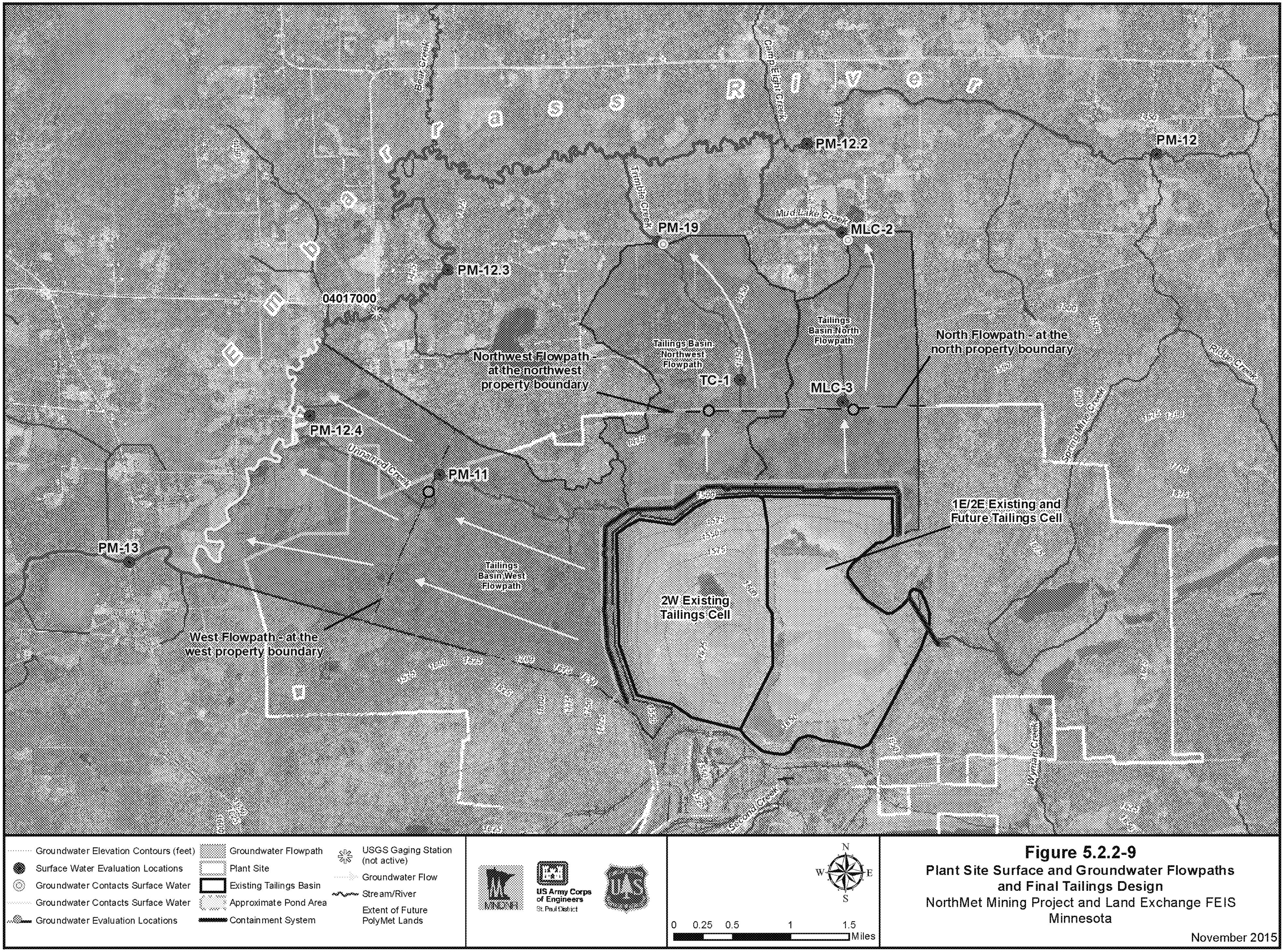


Figure 5.2.2-9
Plant Site Surface and Groundwater Flowpaths and Final Tailings Design
NorthMet Mining Project and Land Exchange FEIS
Minnesota

November 2015

Table 5.2.2-23 Mine Site Groundwater – Maximum P90 Solute Concentration Over Entire 200-Year Simulation at Each Evaluation Location Based on the GoldSim Probabilistic Model

	FEIS Groundwater Evaluation Criterion			East Pit Category 2/3 Surficial Flowpath at Property Boundary		Overburden Storage and Laydown Area Surficial Flowpath at Old Property Boundary		Ore Surge Pile Surficial Flowpath at Partridge River		WWTF Surficial Flowpath at Property Boundary		West Pit Surficial Flowpath at Property Boundary	
Parameter	**Concentration**	**Units**	**Reference Table**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**
General													
Alkalinity	--	mg/L	5.2.2-2	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
Calcium	--	mg/L	5.2.2-2	18.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	29.0	16.1
Chloride	250	mg/L	5.2.2-2	3.5	0.69	3.7	0.69	0.69	0.69	0.69	0.69	6.5	0.69
Fluoride	2	mg/L	5.2.2-2	0.13	0.08	0.42	0.08	0.08	0.08	0.08	0.08	0.17	0.08
Hardness	--	mg/L	5.2.2-2	77.6	69.9	69.9	69.9	70.0	69.9	70.2	69.9	120	69.9
Sulfate	250	mg/L	5.2.2-2	18.6	10.1	36.2	10.1	10.2	10.1	10.5	10.1	34.0	10.1
Magnesium	--	mg/L	5.2.2-2	7.9	7.3	7.3	7.3	7.3	7.3	7.3	7.3	11.7	7.3
Potassium	--	mg/L	5.2.2-2	4.7	1.7	2.6	1.7	1.7	1.7	1.8	1.7	6.4	1.7
Sodium	--	mg/L	5.2.2-2	16.2	5.6	16.1	5.6	5.6	5.6	5.6	5.6	23.9	5.6
TDS[1]	500	mg/L	5.2.2-2	109	82.0	122.8	82.0	82.2	82.0	82.6	82.0	152	82.0
Metals													
Aluminum	--	µg/L	5.2.2-2	339	58.9	139	58.9	70.1	58.9	79.0	58.9	58.9	58.9
Antimony	6	µg/L	5.2.2-2	0.35	0.25	0.29	0.25	0.25	0.25	0.25	0.25	0.27	0.25
Arsenic	10	µg/L	5.2.2-2	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Barium	2,000	µg/L	5.2.2-2	34.8	33.4	33.4	33.4	33.4	33.4	33.4	33.4	38.1	33.4
Beryllium[2]	0.39	µg/L	5.2.2-1(2)	0.15	0.12	0.16	0.12	0.12	0.12	0.12	0.12	0.27	0.12
Boron	1,000	µg/L	5.2.2-2	30.6	27.5	87.3	27.5	27.5	27.5	27.5	27.5	65.7	27.5
Cadmium	4	µg/L	5.2.2-2	0.28	0.10	0.10	0.10	0.11	0.10	0.11	0.10	1.7	0.10
Chromium III	100	µg/L	5.2.2-2	1.1	0.98	0.98	0.98	0.98	0.98	0.98	0.98	1.8	0.98
Cobalt	--	µg/L	5.2.2-2	10.5	0.94	0.94	0.94	1.7	0.94	1.8	0.94	33.1	0.94
Copper	1,000	µg/L	5.2.2-2	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Iron	--	µg/L	5.2.2-2	1,721	1,673	1,673	1,673	1,676	1,673	1,681	1,673	1,673	1,673
Lead	--	µg/L	5.2.2-2	0.86	0.65	0.65	0.65	0.65	0.65	0.66	0.65	5.2	0.65
Manganese[2]	1,002	µg/L	5.2.2-1(2)	645	635	635	635	636	635	636	635	635	635
Nickel	100	µg/L	5.2.2-2	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Selenium	30	µg/L	5.2.2-2	0.72	0.53	0.61	0.53	0.53	0.53	0.54	0.53	1.3	0.53
Silver	30	µg/L	5.2.2-2	0.14	0.11	0.44	0.11	0.11	0.11	0.11	0.11	0.16	0.11
Thallium[2]	0.6	µg/L	5.2.2-2	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Vanadium	50	µg/L	5.2.2-2	4.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	7.0	3.7
Zinc	2,000	µg/L	5.2.2-2	19.2	4.5	4.5	4.5	4.8	4.5	5.2	4.5	106	4.5

Source: PolyMet 2014v.

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
1 Groundwater evaluation criteria.
2 Surficial groundwater.

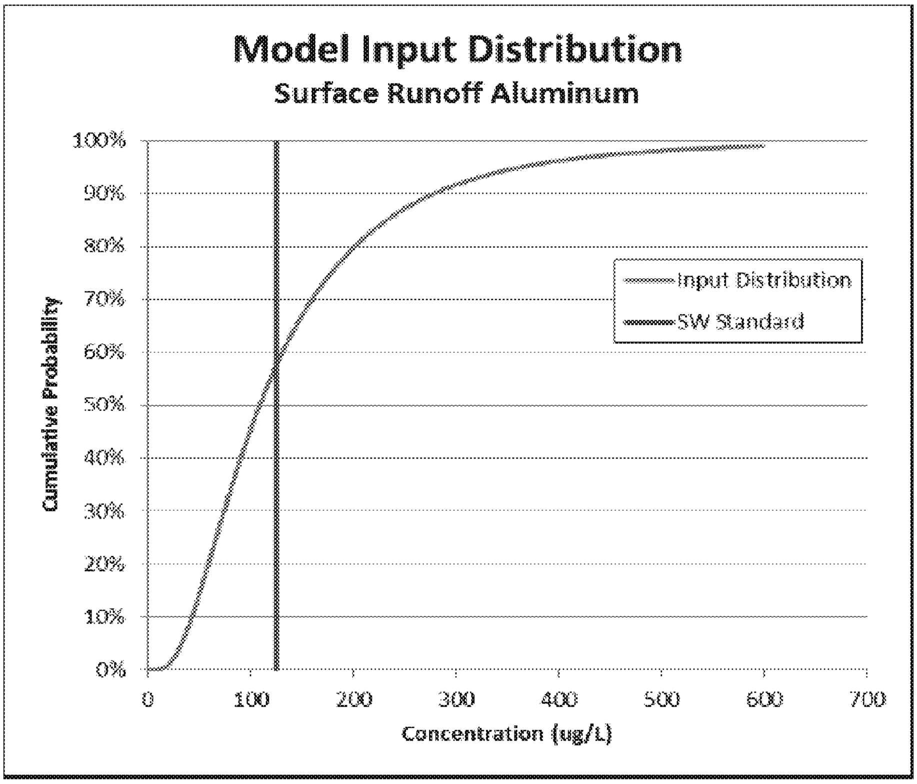
Table 5.2.2-31 Mine Site Surface Water – Maximum P90 Solute Concentration Over Entire 200-Year Simulation with Initial Screening of Constituents without Hardness-Based Evaluation Criteria

			SW-002		SW-003		SW-004		SW-004a		SW-004b		SW-005		SW-006	
Parameter	**Partridge Evaluation Criteria**	**Units**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**	**NorthMet Project Proposed Action**	**CEC Scenario**
General																
Alkalinity	NA	mg/L	152.7	152.4	150.8	150.7	150.6	150.6	152.4	152.9	150.5	150.8	147.4	147.9	145.8	146.3
Calcium	NA	mg/L	38.0	38.0	37.9	37.8	37.9	37.8	38.0	38.0	37.9	37.9	36.9	36.9	36.7	36.7
Chloride	230	mg/L	16.9	16.9	16.8	16.8	16.8	16.7	16.8	16.9	16.8	16.8	16.4	16.4	16.4	16.4
Fluoride	NA	mg/L	0.21	0.21	0.21	0.20	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20
Hardness	500	mg/L	135.9	135.8	133.9	132.9	133.3	132.6	134.7	135.2	134.4	134.4	131.7	131.7	131.4	131.4
Magnesium	NA	mg/L	15	15	14.9	14.9	14.6	14.5	14.4	14.5	14.3	14.3	13.9	13.9	13.9	14
Potassium	NA	mg/L	5.01	5.01	4.98	4.97	5.03	4.97	4.98	5.02	4.96	4.98	4.86	4.88	4.83	4.84
Sodium	NA	mg/L	13.2	13.1	13.1	13	13.1	12.9	23.8	13.2	15.9	13.1	13.2	12.8	13.3	13
Sulfate	NA / 10[(1)]	mg/L	27.3	27.3	27.1	27.1	26.4	26.3	24.3	24.2	22.1	22	**18.3**	**18.2**	17.6	17.6
TDS	700	mg/L	207	207	205	205	204	204	214	204	202	200	192	192	190	191
Metals Total																
Aluminum	125	µg/L	**313.3**	**313.1**	**312.1**	**311.6**	**311.8**	**311.5**	310.2	314.9	310.1	312.6	307.5	308.8	305.6	308.0
Antimony	31	µg/L	0.25	0.25	0.25	0.25	0.26	0.25	4.15	0.25	2.59	0.25	1.39	0.25	1.13	0.25
Arsenic	53	µg/L	2.59	2.59	2.58	2.58	2.59	2.59	2.69	2.64	2.62	2.62	2.62	2.61	2.61	2.59
Barium	NA	µg/L	31.1	31.2	29.9	30.0	28.3	28.5	34.8	30.5	31.4	29.0	25.8	23.9	24.7	22.8
Beryllium	NA	µg/L	0.12	0.12	0.12	0.12	0.12	0.12	0.25	0.12	0.20	0.12	0.15	0.11	0.14	0.11
Boron	500	µg/L	199.7	199.4	197.8	196.4	197.5	196.7	199.7	201.7	198.2	199.3	195.3	195.5	192.8	193.1
Cadmium	NA[2]	µg/L	0.17	0.17	0.16	0.16	0.16	0.16	0.93	0.17	0.57	0.16	0.34	0.16	0.28	0.16
Chromium III	NA[2]	µg/L	1.44	1.44	1.44	1.44	1.44	1.44	1.74	1.47	1.48	1.48	1.46	1.46	1.44	1.45
Cobalt	5	µg/L	1.29	1.29	1.29	1.29	1.29	1.28	3.11	1.29	2.21	1.29	1.58	1.25	1.44	1.27
Copper	NA[2]	µg/L	3.48	3.48	3.44	3.44	3.42	3.41	5.79	3.48	4.47	3.44	3.40	3.34	3.36	3.32
Iron	NA	µg/L	5,917	5,913	5,858	5,845	5,850	5,843	5,864	5,933	5,824	5,890	5,746	5,765	5,710	5,728
Lead	NA[2]	µg/L	0.94	0.94	0.92	0.92	0.92	0.92	1.85	0.97	1.37	1.03	1.06	1.05	1.05	1.05
Manganese	NA	µg/L	575.2	575.4	548.2	549.0	523.2	522.9	443.6	568.0	452.1	533.7	403.9	442.4	395.0	419.3
Nickel	NA[2]	µg/L	4.35	4.34	4.31	4.29	4.27	4.26	26.7	4.36	16.9	4.31	9.17	4.15	7.77	4.09
Selenium	5	µg/L	1.53	1.53	1.52	1.52	1.51	1.51	1.54	1.54	1.53	1.52	1.49	1.49	1.50	1.49
Silver	1	µg/L	0.11	0.11	0.11	0.11	0.11	0.11	0.16	0.11	0.14	0.11	0.12	0.11	0.12	0.11
Thallium	0.56	µg/L	0.12	0.12	0.12	0.12	0.11	0.11	0.11	0.12	0.11	0.11	0.09	0.09	0.09	0.09
Vanadium	NA	µg/L	3.57	3.57	3.47	3.47	3.38	3.34	6.72	3.51	5.28	3.40	3.87	2.92	3.62	2.82
Zinc	NA[2]	µg/L	25.4	25.4	25.6	25.5	25.5	25.4	48.7	25.4	32.7	25.6	25.9	25.5	27.0	25.9

Source: PolyMet 2015m and PolyMet 2014v

Notes:
CEC = Continuation of Existing Conditions
Bold value indicates non-hardness based constituent was retained for secondary screening.
1 Sulfate 10 mg/L wild rice evaluation criterion applies at SW-005 and SW-006
2 Parameter has a hardness-based evaluation criterion and is screened using the secondary screening procedure (see Table 5.2.2-32)

As shown in Table 5.2.2-31 comparing the modeled CEC scenario concentrations in the Upper Partridge River with the modeled NorthMet Project Proposed Action concentrations indicates that although aluminum concentrations in the Upper Partridge River would exceed the evaluation criterion, the concentrations are predicted to be about the same as they would be under the CEC scenario. Therefore, it is predicted that the NorthMet Project Proposed Action would not have a measurable adverse effect on aluminum concentrations in the Upper Partridge River. In addition, as indicated in Figure 5.2.2-32, the concentrations of aluminum in background surface runoff (i.e., non-contact water) exceed the evaluation criterion of 125 µg/L approximately 20 percent of the time. This suggests that the modeled aluminum exceedances are attributable to background surface runoff, which is naturally high in aluminum, and not to effects related to the NorthMet Project Proposed Action.



Source: PolyMet 2015m

Figure 5.2.2-32 GoldSim Input – Cumulative Probability Distribution for Aluminum in Surface Runoff

<u>*Sulfate in the Partridge River*</u>

Evaluation locations SW-005 and SW-006 are located in portions of the Partridge River that the MPCA staff has previously recommended as being waters used for production of wild rice, and therefore subject to the 10 mg/L wild rice sulfate evaluation criterion. As shown in Table 5.2.2-31, the maximum P90 sulfate concentrations at SW-005 and SW-006 for the NorthMet Project Proposed Action are 18.3 and 17.6 mg/L, respectively, which exceed the 10 mg/L criterion. The CEC scenario, however, would also exceed the wild rice evaluation criterion. The analysis below focuses on SW-005 because the NorthMet Project Proposed Action would have greater effects (higher sulfate concentrations) at this location compared to SW-006. Inspection of the GoldSim outputs verifies that predicted sulfate concentrations at SW-006 are always slightly lower than at SW-005 due to dilution effects.

SW-005 shows a dramatic reduction in sulfate concentration after mine year 55 (see Figure 5.2.2-33). Up to this time, the Northshore Mine is modeled as continuously discharging 2.6 cfs of mine water to the Partridge River with a sulfate concentration of 28 mg/L. After mine year 55, there would no longer be a Northshore Mine discharge, but the WWTF would have begun to discharging approximately 0.67 cfs to the West Pit Overflow Creek with a sulfate concentration of 9 mg/L. As a consequence, the sulfate chemical load from affected water discharged to the river would decrease after mine year 55, but P90 sulfate concentrations would still exceed the evaluation criterion.

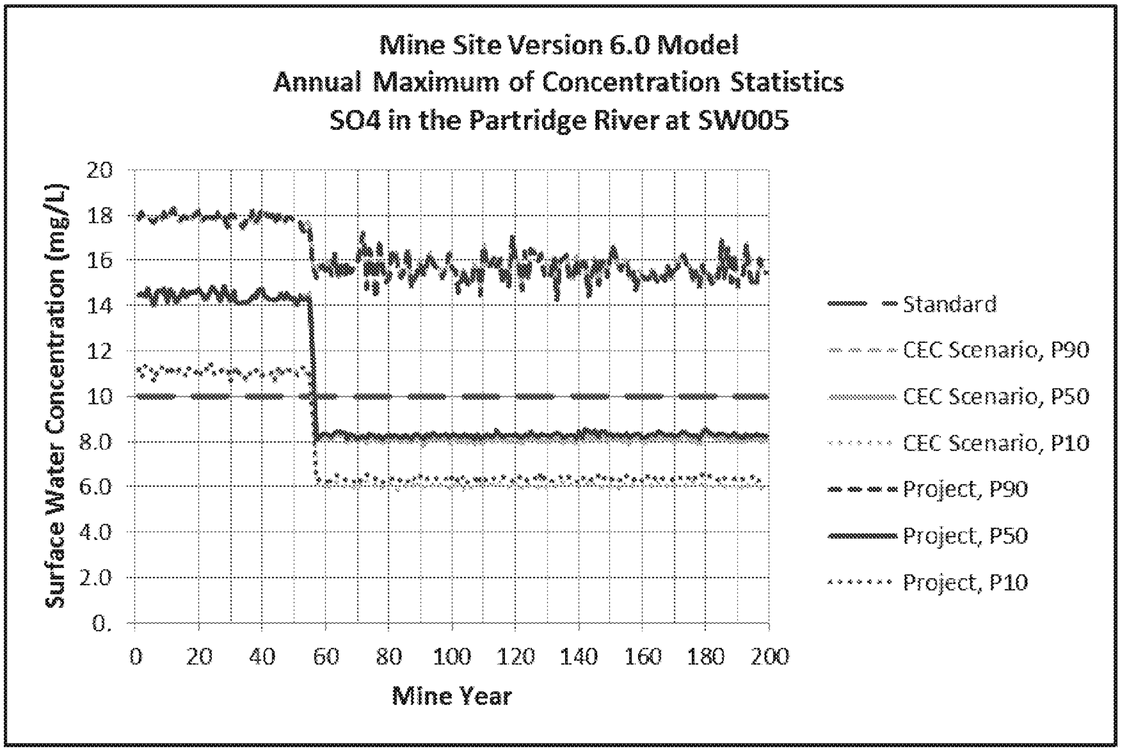


Figure 5.2.2-33 Maximum P90 of Annual Sulfate Concentration at SW-005

Monthly sulfate concentrations in the Partridge River would fluctuate with higher concentrations tending to occur during winter low flows as well as lower concentrations during the spring and summer when increased runoff occurs. For example, Figure 5.2.2-34 shows monthly sulfate concentrations for a representative time period (mine years 30-50) when the Northshore Mine discharges to the Partridge River and the WWTF discharges to the West Pit, but not to the river. Figure 5.2.2-35 is plotted for mine years 140-160 when the WWTF discharges to the Partridge River, all groundwater plumes have reached the river, and the Northshore Mine no longer discharges to the river. As can be seen on both figures, sulfate concentrations fluctuate on an annual basis, with highest concentrations during low-flow conditions (typically January and February) when there is less dilution from surface runoff, which typically has low sulfate concentrations.

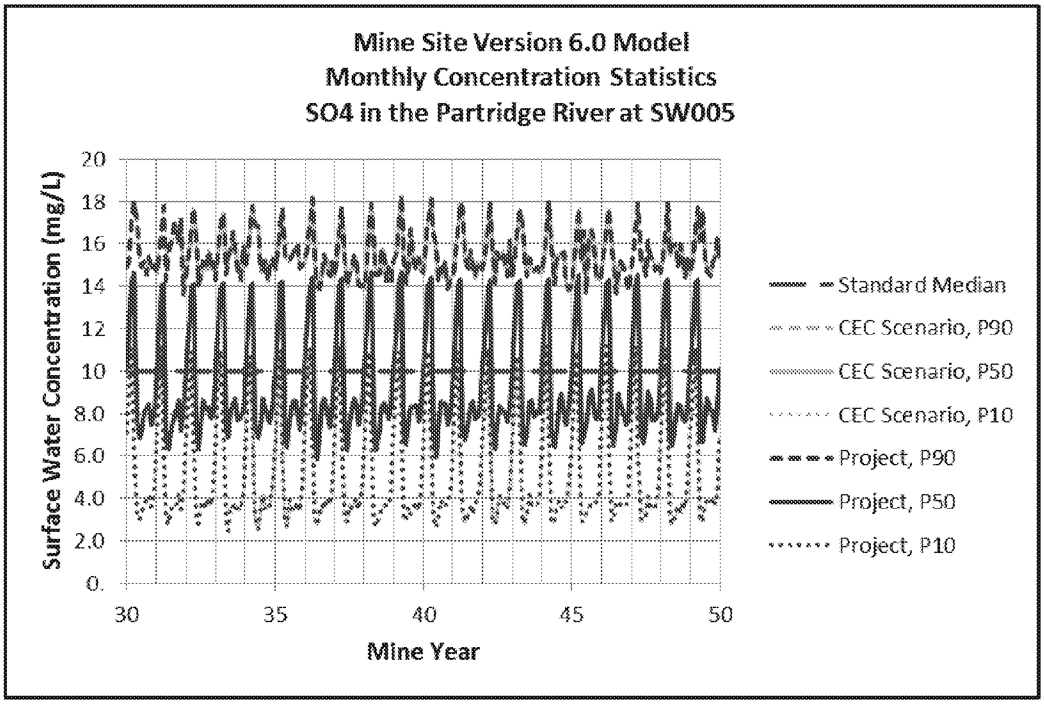


Figure 5.2.2-34 GoldSim-Predicted Sulfate Concentrations at SW-005 for Mine Years 30-50, when Northshore Mine Discharges to the Partridge River and the WWTF Discharges to the West Pit (and not to the River)

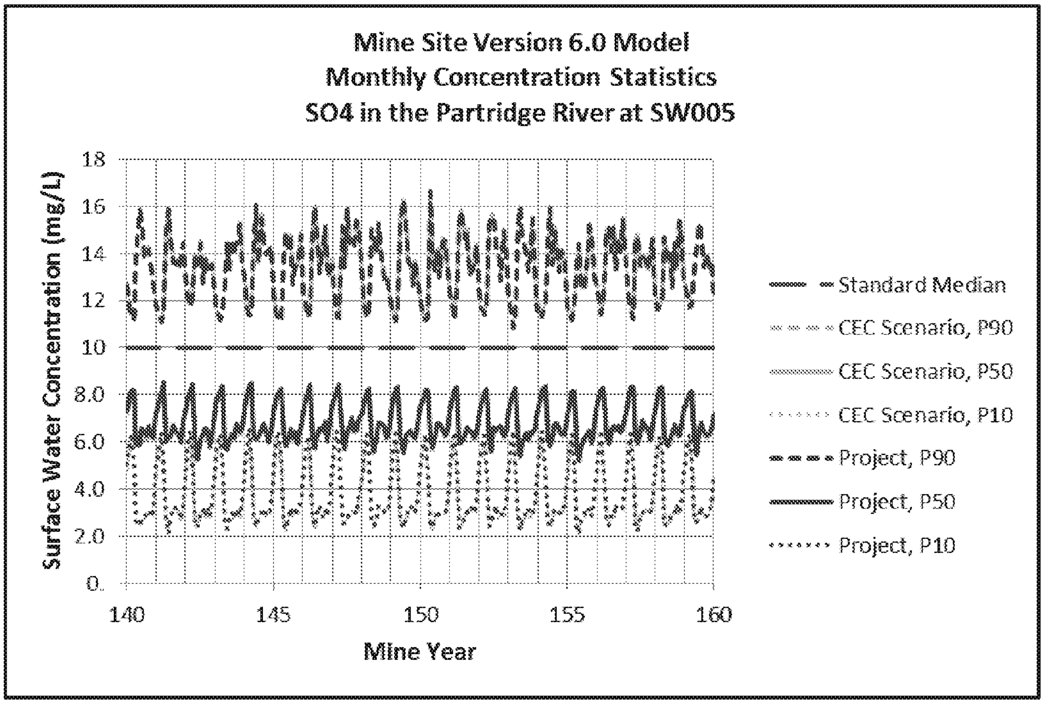


Figure 5.2.2-35 GoldSim-Predicted Sulfate Concentrations at SW-005 for Mine Years 140 -160 when the WWTF Discharges to the Partridge River, Groundwater Plumes have Reached the River, and Northshore No Longer Discharges to the River

To investigate sulfate at SW-005 in more detail, GoldSim results were evaluated on a timestep-by-timestep basis for both P50 concentrations and P90 concentrations.

Time period 0 to 55 years: During this period, sulfate concentrations at SW-005 would always exceed the evaluation criterion at the P90 level for both the CEC and NorthMet Project Proposed Action scenarios, but under both scenarios this is attributable to background runoff, background groundwater, and the Northshore Mine discharge. The NorthMet Project Proposed Action would have negligible effect on sulfate concentrations in the Partridge River during this period because it would not have any surface discharges and only groundwater from the Overburden Storage and Laydown Area and Category 2/3 Stockpile flowpaths would have reached the Partridge River (initially contributing sulfate load to the river in years 30 and 35, respectively). At SW-005, it is likely that the NorthMet Project Proposed Action would not increase the magnitude of events A or B by greater than 0.3 percent in the Partridge River (see Table 5.2.2-32).

Time period 55 to 200 years: During this period, sulfate concentrations at SW-005 would still always exceed the evaluation criterion at the maximum P90 level for both the CEC and NorthMet Project Proposed Action scenarios, but would be at lower concentrations than during the Year 0 to 55 period because Northshore Mine's discharge would cease. The NorthMet Project Proposed Action's contribution to the sulfate loading increases noticeably because the WWTF begins discharging in Year 52 and the NorthMet Project Proposed Action groundwater from other flowpaths (in addition to the OSLA and East Pit-Category 2/3 Stockpile flowpaths) begins to reach the Partridge River. The WWTF would discharge at a sulfate effluent target of 9 mg/L so it would not add to any exceedances of the evaluation criterion, rather it would provide dilution. The groundwater flowpaths would contribute small volumes (see Table 5.2.2-27), but higher sulfate concentrations to the Partridge River.

Overall, the NorthMet Project Proposed Action would account for approximately 3 percent of the sulfate loadings to the Partridge River at SW-005. The primary sources of sulfate loads would continue to be background runoff and background groundwater. At SW-005, it is likely that the NorthMet Project Proposed Action would not increase the magnitude of events A or B by greater than 1.0 percent in the Partridge River (see Table 5.2.2-32). It should be noted that the GoldSim results show that the evaluation criterion would be met essentially all the time under the NorthMet Project Proposed Action Scenario at the P50 level. A practical consequence of this result is that the effects of the NorthMet Project Proposed Action would likely not be identifiable by the proposed post-operations field monitoring program.

The small sulfate increases are explained by the small amounts of impacted and untreated water leaving the Mine Site, which only occur as groundwater. For P50 predictions during all phases of the NorthMet Project Proposed Action, the maximum amount of impacted and untreated groundwater leaving the site is 0.031 cfs (14 gpm). The maximum impact to the Partridge River would occur when this affected groundwater is released to the Partridge River during low-flow conditions. At SW-005, the average annual 1-day low flow is estimated to be 6.9 cfs (3,100 gpm) when Northshore is discharging (up to year 55) and 5.0 cfs (2,240 cfs) when only the WWTF discharges to the Partridge River (after year 52). Given the contrast between groundwater and river flows, it is apparent that the mass loading associated with groundwater flow from the Mine Site is far too small to impart a noticeable impact on sulfate concentrations in the Partridge River.

Nevertheless, a number of contingency measures could be implemented and adapted as necessary to decrease NorthMet Project Proposed Action effects on the Partridge River. As discussed in Section 5.2.2.3.5, these mitigation measures could include: 1) changes in WWTF effluent sulfate concentration and flow rate, 2) installation of surface and groundwater seepage containment systems, and 3) installation of non-mechanical groundwater treatment systems.

Effects on Surface Water Quality in the Upper Partridge River Tributary Streams

This section discusses the effects on surface water quality in the four Upper Partridge River tributary streams: West Pit Outlet Creek, Wetlegs Creek, Longnose Creek, and Wyman Creek. Surface water quality in these creeks would be affected by ore spillage from the rail cars that would transport ore from the Mine Site to the processing plant during operations. Ore would range in size from 48 inches down to small gravel and dust.

Based on observations at other mining operations using similar side-dump rail cars, it is assumed that spillage is most likely to occur along the first 1,000 meters of rail from the Rail Transfer Hopper (PolyMet 2015q). The railway does not cross any streams along this stretch. Rainfall contacting the spilled ore would have the potential to release contaminants, but the relatively small volume of material and dilution from other sources are expected to result in surface water quality meeting the evaluation criteria (PolyMet 2015q). During closure, there may be residual effects on surface water quality from the spilled ore, although the small quantity of expected spilled material would become rapidly depleted of sulfide materials compared to the much larger waste rock stockpiles (PolyMet 2015q).

Three potential ways that ore could be released to the environment during transport via rail car include: 1) ore spillage through the hinge gap, 2) ore spillage through the door gap, and 3) dust from the top of the car. To guard against possible adverse effects from spilled ore, PolyMet plans to refurbish the ore cars, tightening or replacing the couplings and linkages to minimize gaps along the hinges and joint areas where spillage could occur (PolyMet 2014a). The quantity of ore that could potentially spill through the door and hinge gaps of a single refurbished ore car is estimated to be 0.20 tons per year. This is a 97 percent reduction from the originally calculated value of 6.14 tons per year of unrefurbished cars (PolyMet 2015q).

Water quality monitoring is recommended downstream from the rail line on the Partridge River tributary streams to check for any potential deteriorations of water quality over time from ore spillage, and, if detected, adaptive water management measures would be implemented. Dust could be mitigated by spraying water on the loaded ore prior to transport. If significant accumulation of ore spillage occurs, it would be removed.

The West Pit Outlet Creek would also receive effluent from the WWTF during closure, which is estimated at an annual average discharge rate of 0.65 cfs. The WWTF is designed to meet all surface water quality standards with its discharge.

Effects on Surface Water Quality in Colby Lake and Whitewater Reservoir

Secondary screening for Colby Lake constituents with hardness-based evaluation criteria is shown in Table 5.2.2-32. As indicated on the table, there are no hardness-based constituents that exceed screening evaluation thresholds for frequency and magnitude of potential impacts. Table 5.2.2-34 provides maximum P90 concentrations for Colby Lake along with the initial screening results for constituents that do not have hardness-based evaluation criteria. As indicated in Table

5.2.2-34, aluminum, arsenic, iron, and manganese have maximum P90 concentrations that exceed their associated evaluation criteria. However, only arsenic has a maximum P90 NorthMet Project Proposed Action concentration greater than corresponding CEC concentration; therefore, it is retained for further evaluation in secondary screening (Table 5.2.2-32).

Table 5.2.2-34 Colby Lake – Maximum P90 Solute Concentration Over Entire 200-Year Simulation with Initial Screening of Constituents without Hardness-Based Evaluation Criteria

Parameter	Colby Lake Evaluation Criteria	Units	CEC Scenario	PA	% Change from CEC Scenario
General					
Alkalinity	NA	mg/L	130	129	-0.3%
Calcium	NA	mg/L	35.1	35.1	0%
Chloride	230	mg/L	15.3	15.3	-0.2%
Fluoride	4	mg/L	0.19	0.19	0.2%
Hardness	500	mg/L	133	133	-0.3%
Magnesium	NA	mg/L	14.0	14.0	0%
Potassium	NA	mg/L	4.00	3.97	-0.6%
Sodium	NA	mg/L	12.0	12.0	0.1%
Sulfate	250	mg/L	69.8	69.3	-0.9%
TDS	500	mg/L	150	150	-0.1%
Metals Total					
Aluminum[2]	125	µg/L	266	266	-0.3%
Antimony	5.5	µg/L	0.26	0.48	85.9%
Arsenic	2	µg/L	2.44	**2.46**	0.9%
Barium	2,000	µg/L	16.7	16.9	1.1%
Beryllium	4	µg/L	0.11	0.12	6.7%
Boron	500	µg/L	167	167	-0.2%
Cadmium	NA[1]	µg/L	0.17	0.20	18.5%
Chromium III	NA[1]	µg/L	1.28	1.28	-0.1%
Cobalt	2.8	µg/L	1.22	1.26	3.3%
Copper	NA[1]	µg/L	9.83	9.88	0.5%
Iron[2]	300	µg/L	5,043	5,034	-0.2%
Lead	NA[1]	µg/L	1.26	1.31	3.4%
Manganese[2]	50	µg/L	207	202	-2.2%
Nickel	NA[1]	µg/L	4.42	5.43	22.9%
Selenium	5	µg/L	1.29	1.29	0.3%
Silver	1	µg/L	0.11	0.11	0.9%
Thallium	0.28	µg/L	0.07	0.08	0.5%
Vanadium	NA	µg/L	1.83	2.03	11.3%
Zinc	NA[1]	µg/L	26.7	27.6	3.6%

Source: PolyMet 2014v.

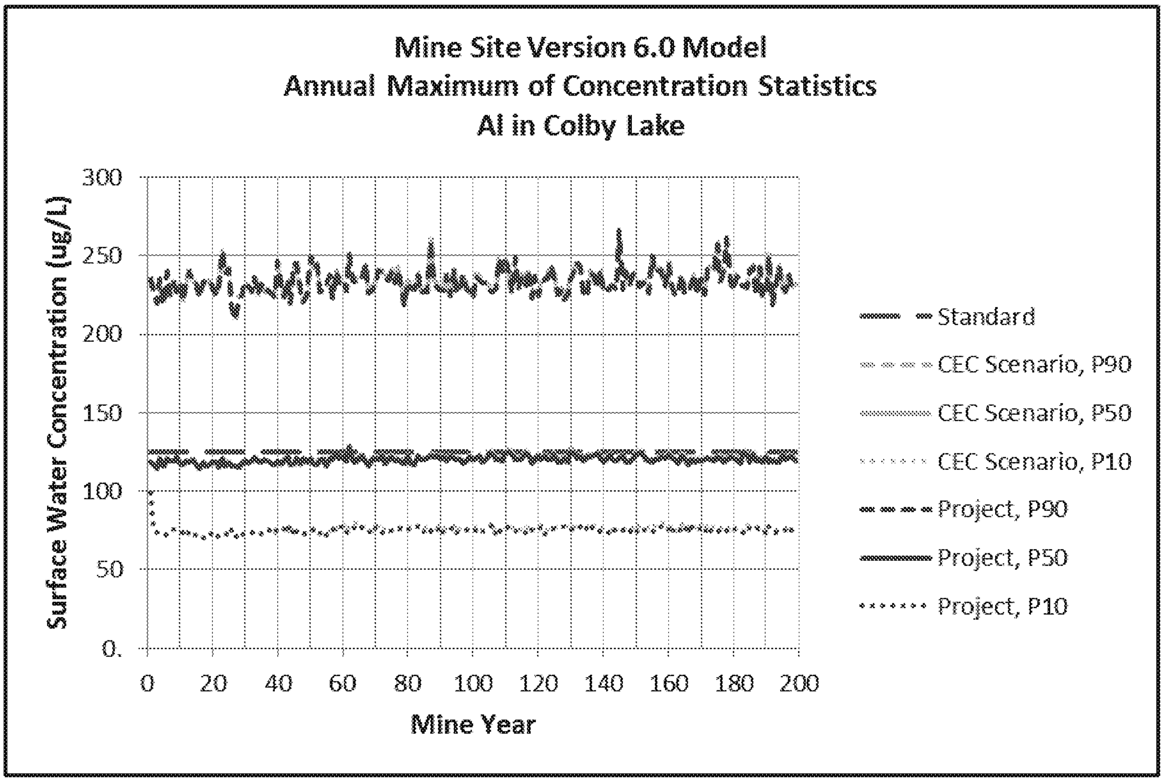
Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
Bold value indicates the constituent is retained for secondary screening
[1] Parameter has a hardness-based evaluation criterion and is screened using the secondary screening procedure (see Table 5.2.2-32).
[2] Carried forward to secondary screening because it is a constituent of interest.

Table 5.2.2-34 above also shows the percent change from the CEC scenario model results. The percent change can appear quite large, but the absolute change is quite small, especially when compared with the evaluation criteria. A good example is nickel, which has a maximum P90 value that increases 22.9 percent, but the absolute increase is approximately 1 µg/L, and the NorthMet Project Proposed Action maximum P90 value (5.43 µg/L) is still well below the evaluation criteria (43.3 µg/L). Note that for aluminum, iron, and manganese, the maximum P90 concentration for CEC is lower than the comparable value for the NorthMet Project Proposed Action. For arsenic, the CEC value is lower by 0.9 percent.

All constituents evaluation for Colby Lake passed secondary screening, so no further analysis is required. However, four constituents were evaluated further because they are of interest.

Aluminum

Model results indicate that the maximum P90 concentration of aluminum (266 µg/L) would exceed the evaluation criteria (125 µg/L) in Colby Lake, just as it is predicted to exceed along most of the Partridge River (see Figure 5.2.2-36). Though intial screening shows a slight decrease in concentraions, this constituent was retained for secondary screening (see Table 5.2.2-32) and is discussed further below.



Source: PolyMet 2014v.

Figure 5.2.2-36 Colby Lake Annual Maximum Aluminum Concentrations

Table 5.2.2-43 Plant Site Embarrass River Surface Water – Maximum P90 Solute Concentration

Parameter	Stream Standard	Units	PM-12		PM-12.2		PM-13	
General			**PA**	**CEC Scenario**	**PA**	**CEC Scenario**	**PA**	**CEC Scenario**
Alkalinity	NA	mg/L	100	100	100	100	101	179
Calcium	NA	mg/L	23.4	23.4	41.5	41.5	33.9	49.3
Chloride	230	mg/L	10.1	10.1	9.9	9.9	9.7	13.1
Fluoride	NA	mg/L	0.21	0.21	0.21	0.21	0.21	1.4
Hardness	500	mg/L	96.7	96.7	463	463	208	453
Magnesium	NA	mg/L	12.3	12.3	88.3	88.3	31.6	81.3
Potassium	NA	mg/L	2.44	2.44	18.6	18.6	6.19	9.13
Sodium	NA	mg/L	5.41	5.41	32.9	32.9	12.5	42.1
Sulfate(2)	NA	mg/L	14.3	14.3	375	375	114	217
TDS	700	mg/L	128	128	626	626	269	521
Metals Total								
Aluminum	125	µg/L	188	188	180	180	**180**	**179**
Antimony	31	µg/L	0.36	0.36	0.33	0.33	9.17	0.40
Arsenic	53	µg/L	4.36	4.36	4.15	4.15	5.81	4.21
Barium	NA	µg/L	49.8	49.8	39.3	39.3	35.4	93.7
Beryllium	NA	µg/L	0.15	0.15	0.14	0.14	0.31	0.33
Boron	500	µg/L	26.5	26.5	70.1	70.1	151	225
Cadmium	NA1	µg/L	0.11	0.11	0.11	0.11	1.01	0.15
Chromium III	NA1	µg/L	1.80	1.80	1.71	1.71	4.13	1.70
Cobalt	5	µg/L	2.72	2.72	2.63	2.63	2.96	2.63
Copper	NA1	µg/L	2.06	2.06	2.07	2.07	5.67	2.55
Iron	NA	µg/L	12,476	12,476	11,927	11,927	11,808	11,687
Lead	NA1	µg/L	0.50	0.50	0.48	0.48	1.73	0.59
Manganese	NA	µg/L	1,305	1,305	1,279	1,279	1,239	1,247
Nickel	NA1	µg/L	3.23	3.23	3.39	3.39	28.42	4.54
Selenium	5	µg/L	0.78	0.78	0.78	0.78	2.74	0.76
Silver	1	µg/L	0.13	0.13	0.13	0.13	0.18	0.14
Thallium	0.56	µg/L	0.13	0.13	0.13	0.13	0.17	0.15
Vanadium	NA	µg/L	3.68	3.68	4.23	4.23	6.53	3.73
Zinc	NA1	µg/L	19.0	19.0	18.3	18.3	57.0	18.5

Source: PolyMet 2014w.

Notes:
Bold value indicates the non-hardness based constituent was retained for secondary screening.
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action

1 Parameter has a hardness-based evaluation criterion and is screened using the secondary screening procedure (see Table 5.2.2-44).

2 Sulfate 10 mg/L wild rice evaluation criterion applies at PM-13.

greater aluminum load to Mud Lake Creek under the NorthMet Project Proposed Action compared to the CEC. The larger Mud Lake Creek watershed area under the NorthMet Project Proposed Action is responsible for the higher associated modeled aluminum concentrations. The higher aluminum concentrations in Mud Lake Creek are related to natural surface runoff and not to chemical sources associated with chemical sources from the NorthMet Project Proposed Action.

Constituents of Interest

Lead in Surface Water at PM-11

Examination of GoldSim outputs show that when lead concentrations at PM-11 are predicted to be elevated, the flow at PM-11 is dominated by WWTP discharges. In GoldSim, the WWTP effluent lead concentration is assumed to be 3 µg/L, which is the water quality standard for lead at the hardness of the discharge. Pilot testing of the proposed WWTP processes (Barr 2013f) has indicated that the WWTP is capable of discharging lead at lower concentrations, so the 3 µg/L concentration used in GoldSim is likely a higher value than what would actually be achieved. In addition, if necessary engineering modifications to the proposed WWTP could be made to ensure that WWTP effluent would have lead concentrations less than or equal to 2 µg/L. See Section 5.2.2.3.5 for a brief description of what adaptive mitigation measures could be made to achieve a lead effluent concentration of 2 µg/L.

To investigate the effect on WWTP effluent lead concentration on surface water concentrations at PM-11, a subsidiary GoldSim simulation (PolyMet 2015s) was performed for which the only change to the inputs was lowering the assumed WWTP effluent lead concentration from 3 to 2 µg/L. In making this change, the predicted frequency of lead exceedance at PM-11 (when the CEC scenario does not exceed) was reduced to 1.3 percent, which is substantially less than the 5 percent screening threshold. Given that pilot testing shows that 2 µg/L lead concentration is achievable in the WWTP effluent, it is likely that actual lead concentrations at PM-11 would have acceptably low frequencies of exceedance. If however, the proposed WWTP generates effluent with higher lead concentrations than expected, adaptive engineering measures could be invoked at the WWTP to lower the frequency of lead exceedances (see Section 5.2.2.3.5).

Sulfate in Surface Water in the Embarrass River

For the Embarrass River, the only surface water evaluation location that has a sulfate evaluation criterion is PM-13, because it has been previously identified as a draft MPCA staff-recommended wild rice production water. Therefore, a sulfate evaluation criterion of 10 mg/L was established for this FEIS. As shown in screening Table 5.2.2-43, the GoldSim maximum P90 concentration at PM-13 for the CEC scenario is 179 µg/L, which is well above 10 mg/L. Given that existing sulfate at PM-13 is above the evaluation criterion, the MPCA developed a set of specific water quality performance criteria for sulfate at the Plant Site. These are each evaluated at the end of this section.

As with the previous sections, Table 5.2.2-47 shows predicted maximum P50 and P90 annual sulfate concentrations at PM-13, and PM-12 and PM-12.2 for comparison. The table provides the following observations:

- At PM-12 and PM-12.2, there is virtually no change in sulfate between CEC scenario and NorthMet Project Proposed Action conditions.
- In progressing downstream from PM-12 to PM-12.2, there is generally a large increase in sulfate concentrations.
- The GoldSim-predicted PM-13 sulfate concentrations for both the NorthMet Project Proposed Action and the CEC scenario are significantly higher than historically measured sulfate at PM-13.
- At PM-13, the concentration for the NorthMet Project Proposed Action is generally about 100 mg/L less than the associated CEC scenario.
- At PM-13, there are no cases (both the NorthMet Project Proposed Action and CEC) where sulfate is below the 10 mg/L wild rice evaluation criterion.

Table 5.2.2-47 Maximum P50 and Maximum P90 of Annual Sulfate Concentrations for Different Project Phases

Evaluation Location	Evaluation Criterion	Operations (years 2-20)		Reclamation (years 21-55)		Post-Closure Maintenance (years 56-200)	
		PA	CEC	PA	CEC	PA	CEC
a. Maximum P50 of Annual Concentrations from GoldSim Output							
PM-12	NA	5.6	5.6	5.7	5.7	5.7	5.7
PM-12.2	NA	294	294	294	294	294	294
PM-13	10	89	188	89	185	90	185
b. Maximum P90 of Annual Concentrations from GoldSim Output							
PM-12	NA	12.6	12.6	14.0	14.0	14.3	14.3
PM-12.2	NA	367	367	368	368	371	371
PM-13	10	113	209	114	217	114	217

Notes:
CEC = Continuation of Existing Conditions
PA = NorthMet Project Proposed Action
Highlighting indicates where PA is above the evaluation criterion; however, in all these cases, PA is less than the corresponding CEC concentration.
All concentrations are in mg/L.

The similarity of CEC scenario and the NorthMet Project Proposed Action is reasonable for PM-12 and PM-12.2 because these evaluation locations are upstream of all mine facilities and would not be expected to exhibit any effects from the NorthMet Project Proposed Action. Also, the increase in sulfate at PM-12.2 is explained by surface discharge from Pit 5NW, which enters the Embarrass River just upstream of PM-12.2 and has sulfate concentrations of about 1,000 mg/L. The chemical sulfate load from Pit 5NW largely controls the magnitude of sulfate in downstream portions of the Embarrass River including PM-13.

As discussed in Section 4.2.2.3.2, the current increase in the Embarrass River chloride load in going from PM-12.2 (upstream of Plant Site) to PM-13 (downstream of Plant Site) provides reasonable evidence that nearly all surface seepage from the northern, northwestern, and western sides of the LTVSMC Tailings Basin is reaching the Embarrass River. It is estimated that this surface seepage is about 2,400 gpm and has an average sulfate concentration of about 230 mg/L, so that the associated sulfate load leaving the Tailings Basin is about 3,000 kg/day. However the plot of sulfate load in the Embarrass River (see Figure 4.2.2-51) indicates that between PM-12.2 and PM-13, the sulfate load increases by only about 200 kg/day. In Section 4.2.2.3.2, it is hypothesized that there is a natural process that sequesters sulfate in wetlands between the Tailings Basin and the Embarrass River and this explains the reduced sulfate load from the Tailings Basin to the Embarrass River. For conservativeness, the GoldSim model was programmed to *not* consider any loss of chemical load in surface flow between the Tailings Basin and the Embarrass River. As consequence, the model would be expected to overestimate sulfate concentrations at PM-13, with the difference being greater for CEC scenario for which there is no capture of the Tailings Basin surface seepage. This effect is illustrated on Figure 5.2.2-50, which uses cumulative probability to compare GoldSim predicted sulfate with measured sulfate at PM-13. The figure shows that GoldSim-predicted sulfate concentrations for both the NorthMet Project Proposed Action and the CEC scenario are greater than measured sulfate at PM-13. In recognition of GoldSim's tendency to overestimate sulfate concentrations at PM-13, evaluation of the NorthMet Project Proposed Action is oriented toward comparing the *difference* between the NorthMet Project Proposed Action and CEC scenario values, rather than focusing on the magnitude of predicted concentrations.

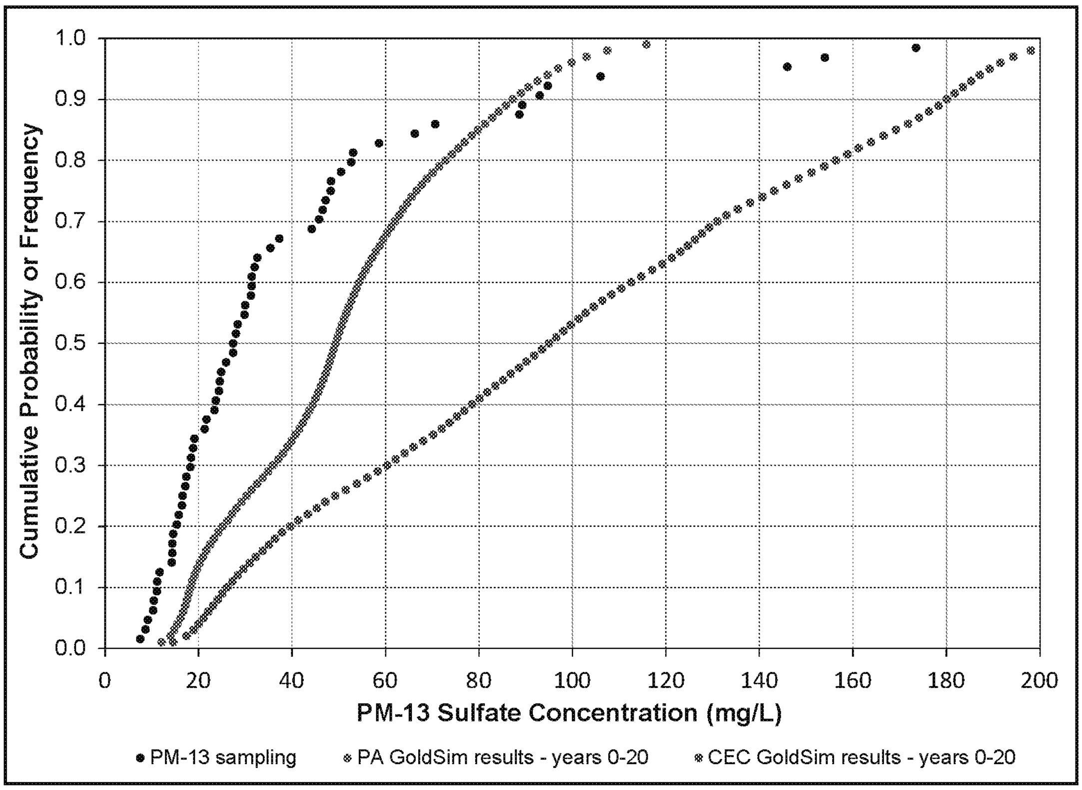


Figure 5.2.2-50 Comparison of Measured and Modeled Sulfate Concentrations at PM-13

Figure 5.2.2-51 shows GoldSim-predicted sulfate concentrations at PM-13. For sampling, NorthMet Project Proposed Action and CEC scenario plots, the model predicts that sulfate at PM-13 would be substantially reduced under the NorthMet Project Proposed Action compared to the CEC scenario. Although the model may overestimate the magnitude of sulfate concentrations, the relative reduction in concentrations at PM-13 is apparent. This result is explained by the engineering controls associated with the NorthMet Project Proposed Action. Currently there is about 2,400 gpm of surface seepage leaving the northern, northwestern, and western sides of the Tailings Basin that contains sulfate concentrations of about 230 mg/L. Under the CEC scenario, all Tailings Basin seepage reaches the Embarrass River and contributing its sulfate load to the Embarrass River. Under the NorthMet Project Proposed Action, nearly all of the surface seepage would be collected by the seepage containment system and sent to the WWTP. To augment the flow loss, at least 80 percent of the captured flow rate would be discharged to the tributaries after treatment has reduced the sulfate concentration to 9 mg/L. The result is that a substantial reduction in sulfate load to the Embarrass River would occur under the NorthMet Project Proposed Action and this explains the lower sulfate concentrations at PM-13 when compared to the CEC scenario.

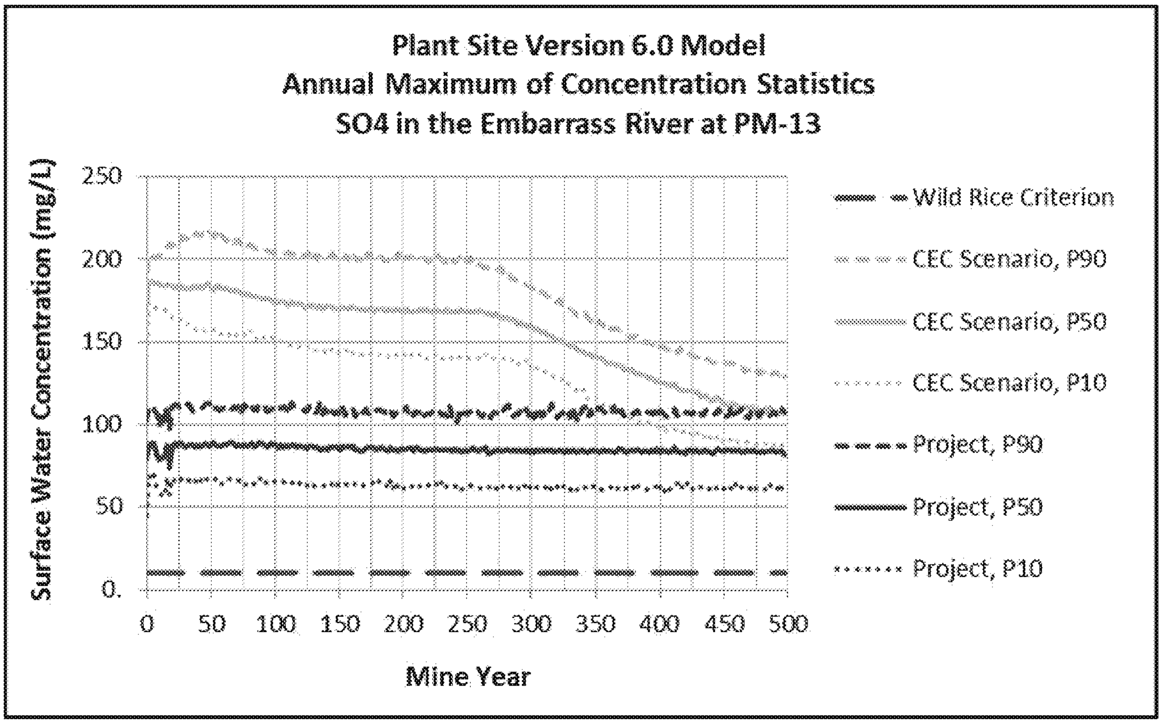


Figure 5.2.2-51 Maximum Annual Sulfate Concentrations at PM-13

The effect of the NorthMet Project Proposed Action on sulfate concentrations in the Embarrass River Watershed is of concern because MPCA has previously recommended waters within and downstream from Embarrass Lake, the northernmost tip of Wynne Lake, and the segment of the Embarrass River from Sabin Lake to the Highway 135 bridge, as waters used for production of wild rice (see Figure 5.2.2-1). Given that current sulfate concentrations at PM-13 are almost always higher than the 10 mg/L wild rice sulfate evaluation criterion, the MPCA has developed three supplemental water quality performance criteria for sulfate at the Plant Site (MPCA 2011d), which are each discussed below.

Performance Criterion 1

No increase in sulfate-loading from existing conditions would occur at PM-11 (Unnamed Creek), PM-19 (Trimble Creek), and MLC-2 (Mud Lake Creek).

Figures 5.2.2-52, 5.2.2-53, and 5.2.2-54 show GoldSim-predicted sulfate loading at PM-11, PM-19, and MLC-2, respectively, based on annual maximum values. As shown, the sulfate-loading at these three locations would be reduced under the NorthMet Project Proposed Action compared to the CEC scenario. The decrease is predicted to occur for P10, P50, and P90 concentrations. The model therefore predicts that this criterion would be met under the NorthMet Project Proposed Action.

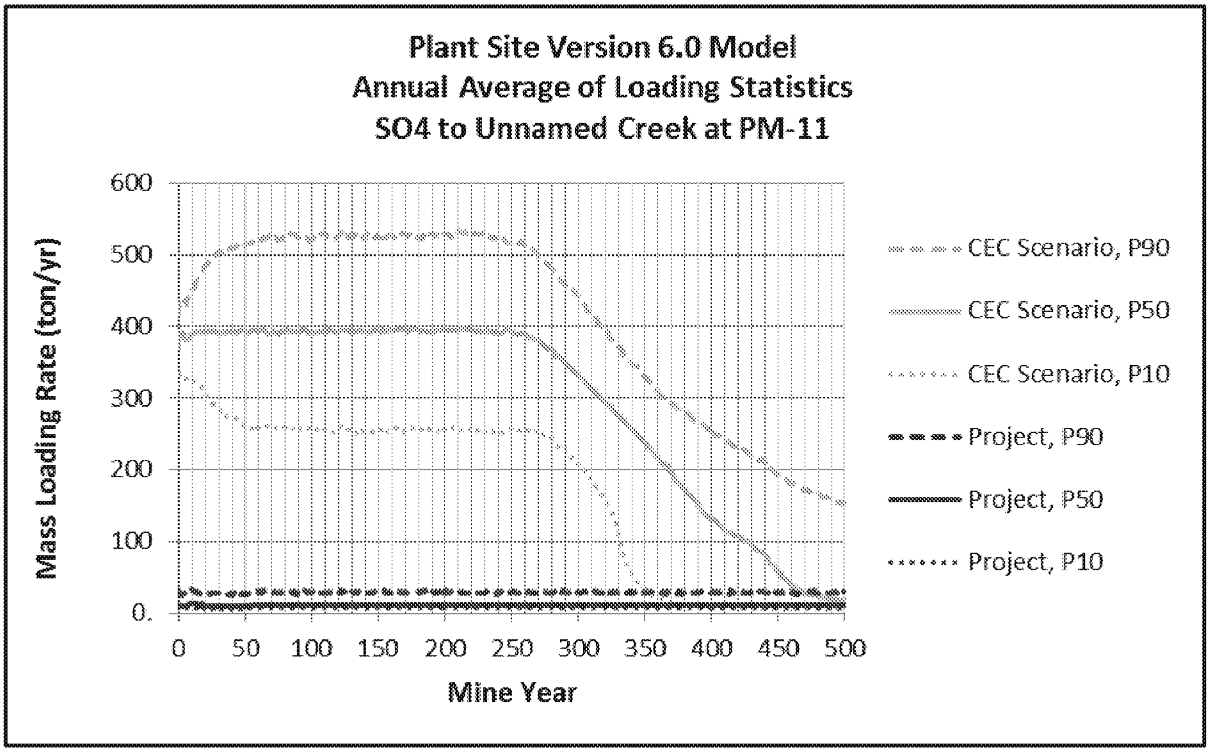


Figure 5.2.2-52 Maximum Annual Sulfate Loading at PM-11

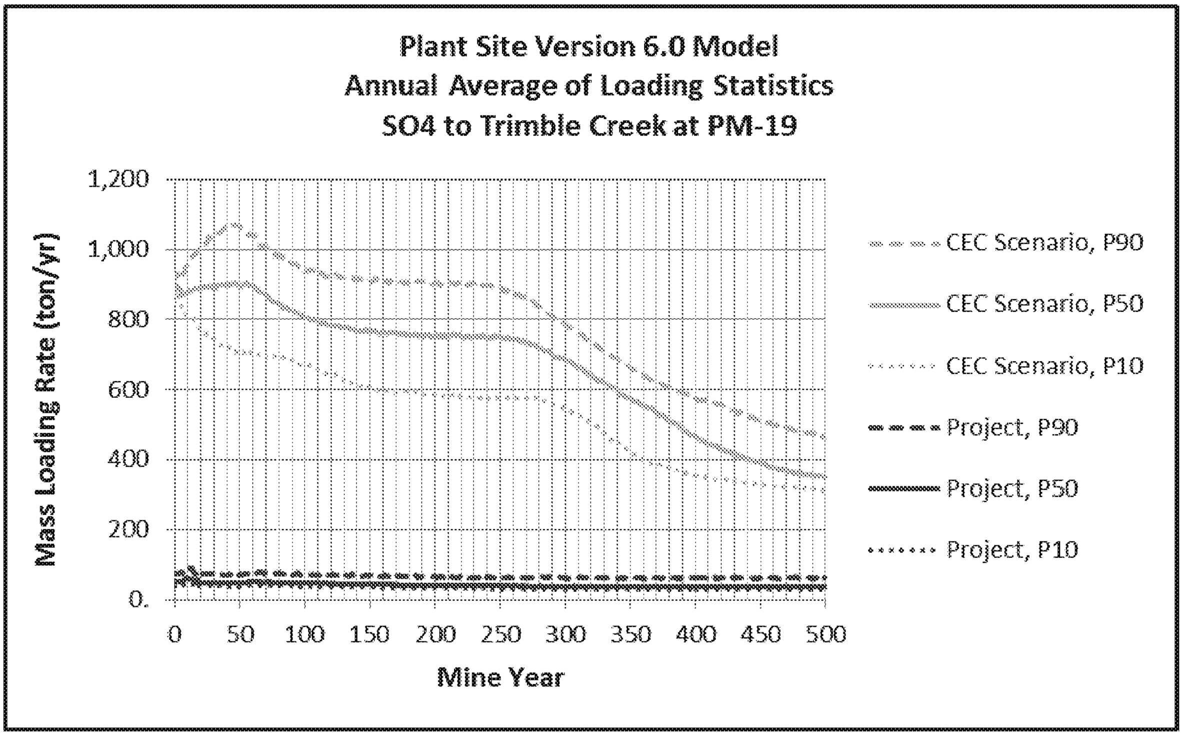


Figure 5.2.2-53 Maximum Annual Sulfate Loading at PM-19

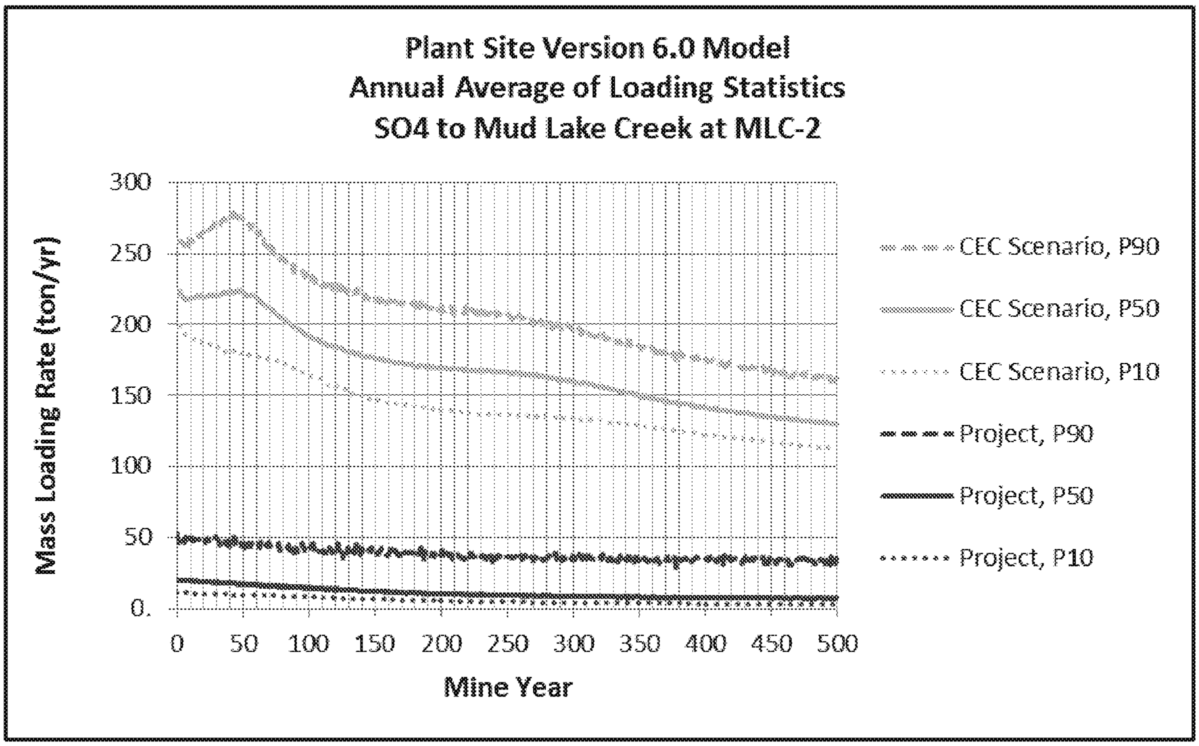


Figure 5.2.2-54 Maximum Annual Sulfate Loading at MLC-2

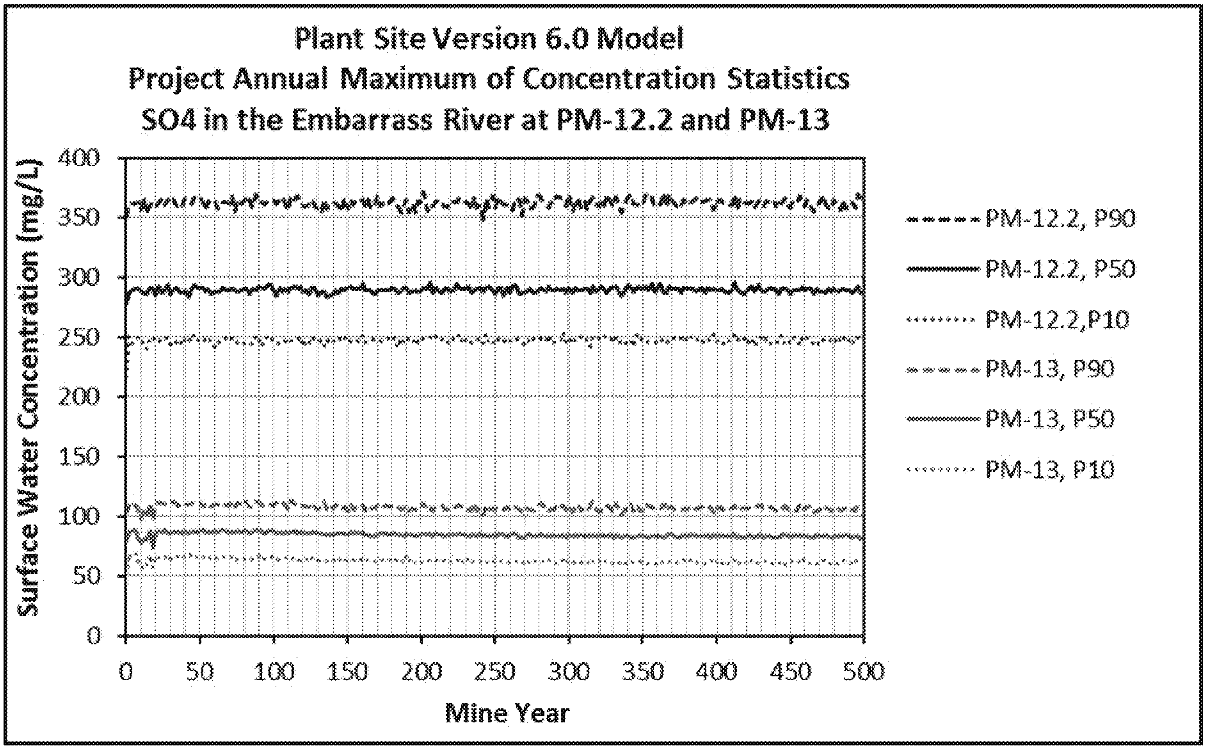


Figure 5.2.2-55 Maximum Annual Sulfate Concentrations at PM-12.2 and PM-13

Performance Criterion 2

The concentration of sulfate in the Embarrass River at PM-13 would decrease from existing condition.

Figure 5.2.2-51 shows GoldSim-predicted sulfate at PM-13 for the NorthMet Project Proposed Action and the CEC scenario. For P90, P50, and P10 values, the sulfate concentrations at PM-13 would be reduced under the NorthMet Project Proposed Action. As discussed previously, this concentration reduction under the NorthMet Project Proposed Action would result from the capture of tailings seepage with high sulfate by the seepage containment system and the discharge of most of this water to the Embarrass River with much lower sulfate due to treatment by the WWTP. The model therefore predicts that this criterion would be met under the NorthMet Project Proposed Action.

Performance Criterion 3

No statistically significant increase in sulfate would occur in the Embarrass River from upstream of the facility (e.g., PM-12.2) to downstream of the facility (e.g., PM-13).

Figure 5.2.2-55 compares GoldSim-predicted annual maximum sulfate concentrations at PM-12.2 with concentrations at PM-13. There are no NorthMet Project Proposed Action activities that would affect concentrations at PM-12.2, so this figure serves as a basis for determining downstream sulfate changes for Proposed Action conditions. Figure 5.2.2-55 shows that under the NorthMet Project Proposed Action, sulfate concentrations would substantially decrease in progressing downstream from PM-12.2 to PM-13, so this criterion would be met under the NorthMet Project Proposed Action.

Plant Site Model Sensitivity Analyses

The sensitivity of the GoldSim Model was evaluated for changes to groundwater recharge rates and climate change. The following sections summarize the sensitivity analysis findings for the Plant Site.

Recharge to Groundwater Sensitivity Analysis

A sensitivity analysis was performed to assess to what extend the model predictive simulation results depend on the definition of recharge (to groundwater) used to set up the NorthMet Plant Site water quality model. This analysis showed that changing the distribution used for aquifer recharge from triangular to lognormal and correlating recharge to precipitation in GoldSim model simulations does result in minor changes to 10th percentile, 50th percentile, and 90th percentile of the model calculated groundwater and surface water concentrations. However, the changes are minimal. Further, the potential to exceed an applicable groundwater and surface water standards is not sensitive to these model input changes (Barr 2015d).

Climate Change Sensitivity Analysis – Plant Site

The potential effects of a climate change upon the predictions of both the GoldSim probabilistic models developed for the Plant Site, the Plant Site NorthMet Project Proposed Action Model and No Action Plant Site NorthMet Project Proposed Action Model, were evaluated by running the "climate change sensitivity analysis." The ranges of precipitation and temperature input parameters were varied following the guidance provided by the Co-lead Agencies (Kellogg 2011). The sensitivity of the model predictions to changes in values of those parameters was quantitatively assessed at the toes of the Tailings Basin and qualitatively assessed at other locations within the model domain. In summary, the Climate Change Sensitivity Analysis Model was set by increasing: 1) the mean annual temperature by 2.0 to 5.2 degrees Celsius, 2) the mean annual precipitation from 28.1 to 29.8 in/yr, and 3) the mean annual open water evaporation by 6.5 percent. The parameter values were linearly increased from mine year 1 to mine year 60 and, then, were kept constant. Such modified model was used to run 200-year predictive simulations, similar to the NorthMet Project Proposed Action Models.

The impacts of the modeled changes upon contaminant concentrations in seepage water at the toes were analyzed for lead, sulfate, copper, and iron. Lead concentrations would change most at the west and northwest toes, up to 13 percent. Similarly, the largest increase in sulfate concentrations, up to 15 percent, would occur at the west and northwest toes. The largest increase in copper concentrations, up to 12 percent, would occur, again, at the west and northwest toes. Finally, the largest increase in iron concentrations, up to 15 percent, would also occur at the west and northwest toes.

Seepage at the toes is expected to increase slightly due to the increased infiltration through the Tailings Basin. Climate change is not expected to cause significant changes in groundwater quality. Likewise, surface water quality in the Embarrass River and its tributaries is expected to be minimally affected by the NorthMet Project Proposed Action under climate change conditions. All water leaving the Tailings Basin's footprint would be treated by the WWTP, except for approximately 21 gpm of seepage that is conservatively expected to escape the Containment System. Runoff from the exterior of the East Dam is relatively inert.

It is likely that the amount of water that would need treatment at the WWTP would increase under climate change conditions. This is because the increase in precipitation would be slightly greater than the amount of water lost to increased evaporation (Barr 2015d).

5.2.2.3.4 Mercury

Mercury can be released to surface water or groundwater through mobilization of mercury stored in rock, soil, peat, and vegetation, and can also be deposited to surface water through atmospheric dry deposition and precipitation. Methylmercury, which is an organic form of mercury, accumulates in fish and is toxic to humans and wildlife at concentrations above a toxicity threshold. Current scientific understanding of the factors and mechanisms affecting mercury methylation and bioaccumulation is limited. Mercury concentrations in fish sampled from downstream lakes presently trigger advice to limit fish consumption. An increase in mercury in fish tissue would be counter to statewide efforts to reduce mercury concentrations in fish.

Mercury was not included in the GoldSim model for either the Mine Site or the Plant Site, as insufficient data and unique modeling requirements for mercury dynamics prevented modeling mercury like the other solutes. Regardless, the NorthMet Project Proposed Action would still need to demonstrate that the mercury evaluation criteria would be protected (see Section 5.2.2.1). Details of overburden management, which includes peat, is included in Section 5.2.2.3.2. Adaptive management has also been identified within the FEIS process that could reduce mercury concentrations if necessary (see Section 5.2.2.3.5). Therefore, a simple mass balance model estimation method was used. This simple estimation method was preferred over a detailed mechanistic model because it incorporated the important input and removal processes for mercury, was very transparent with regard to data inputs, and allowed for easy assessment of the effects of changing parameter values on mercury concentrations. For the Mine Site, this method, in combination with analog data from existing natural and mine pit lakes in the region, was used to assess future mercury concentrations in the West Pit lake and in the overflow water (PolyMet 2015m). A similar mass balance approach was used for the Plant Site to estimate future mercury concentrations released from the Tailings Basin.

The NorthMet Project Proposed Action and project area watershed information used to assess the potential effects on average annual mercury loading and concentrations at the Plant Site and Mine Site (Upper Embarrass River and Upper Partridge River, respectively) were also used in assessing the potential effects from the NorthMet Project Proposed Action on mercury loading in the St. Louis River (Barr 2015f).

This section discusses mercury from only a water-concentration perspective; the potential effects of the NorthMet Project Proposed Action on the bioaccumulation of methylmercury in fish are discussed in Section 5.2.6. Cumulative effects are discussed in Section 6.2.3.3.4 and 6.2.3.5.4.

Direct Release of Mercury to the Partridge River Watershed

The NorthMet waste rock and ore contain trace amounts of mercury. Laboratory analysis of humidity cell leachates from waste rock samples found average total mercury concentrations between 5 and 7 ng/L, with concentrations unrelated to rock type or sulfur content (SRK 2007b).

Separate 36-day batch tests using local rainfall (12 ng/L total mercury) found that contact with Duluth Complex rock actually decreased total mercury concentrations to between 1.9 and 3.2 ng/L as a result of adsorption (SRK 2007b). Therefore, the data suggest that most of the mercury present in rainfall or released by sulfide oxidation is typically adsorbed by other minerals present in the mine waste rock. The primary NorthMet Project Proposed Action-related source of mercury to the Partridge River would be the WWTF discharge.

As discussed previously, there would be no surface water discharges to the Partridge River or its tributaries from the Mine Site until approximately year 52, when the West Pit would be flooded and the overflow would be directed to the WWTF for treatment and discharge. The WWTF discharge would be subject to the GLI standard for mercury (1.3 ng/L). Mercury concentrations in the West Pit were estimated two ways: using analog data from other natural lakes and mine pit lakes in northeastern Minnesota, and using a mass balance approach.

The West Pit, like seepage/headwater lakes (e.g., lakes with no significant inflowing streams), would receive most of its water from precipitation and direct runoff from the surrounding watershed. Water balance modeling estimates that 70 percent of the West Pit inflow after reclamation would be from precipitation. Therefore, natural seepage/headwater lakes and existing mine pits in the vicinity of the NorthMet Project Proposed Action area can provide an analog for mercury concentrations that would occur in the West Pit at the time of overflow. Of particular significance are the Dunka Pit Lakes. Because the Dunka Pit intersects the Duluth Complex, the mercury concentration data from the Dunka Pit Lakes are considered an important indicator of potential total mercury concentrations for the West Pit at closure. Data from 16 mine pit lakes and five natural headwater/seepage lakes in northeastern Minnesota were evaluated. As Table 5.2.2-48 shows, despite the fact that the primary source of inflow to these lakes/pits was precipitation, which averages about 13 ng/L based on the annual average mercury concentration from the National Atmospheric Deposition Program for the Fernberg Road Monitoring Site (2010-2011) (PolyMet 2015m), only two of the lakes/pits had average total mercury concentrations above the GLI standard of 1.3 ng/L (Pit 2W at 1.61 ng/L and Pit 9S at 1.87 ng/L).

Table 5.2.2-48 Total Mercury Concentration Data from Natural Lakes and Mine Pits in Northeastern Minnesota

Lake/Pit Type	Number of Lakes/Pits	Minimum Mercury Concentration[1] (ng/L)	Average Mercury Concentration (ng/L)	Maximum Mercury Concentration[1] (ng/L)	Number with Avg Concentration >1.3 ng/L
Natural Lakes	5	0.34	0.66	1.73	0
Pit Lakes	16	0.5	0.97	2.55	2

Source: PolyMet 2015m.

Note:
[1] Data represent lowest and highest individual samples from lakes.

A mass balance approach was also used to evaluate potential mercury concentrations in the West Pit. For this evaluation, unless otherwise specified, 'mercury' refers to total mercury. Elemental mercury was not a part of the evaluation process, as no elemental mercury releases are anticipated from mining or processing operations. Mass balance models range from simple spreadsheet-based formats to more complex such as the GoldSim model. An important consideration in the selection of a water quality model is the complexity of the chemical being assessed and the available data, and the consideration that a complex situation may not require a complex water quality model (Loucks et al. 2005). The MPCA's spreadsheet-based model allows reviewers to focus on key inputs and their impact on model behavior and results. Furthermore, the use of a separate spreadsheet model for mercury enabled the specification of assumptions that were specifically conservative for mercury but that were not necessarily conservative for other contaminants, for example the depth of the mixing zone (Barr 2015f).

The mass balance took into consideration average inflows and estimated potential mercury inputs from precipitation, atmospheric dry deposition, groundwater inflow, Category 1 Stockpile drainage, other stormwater runoff within the Mine Site, supplemental water from the Plant Site WWTP, collected seepage from the Tailings Basin, and inflows from the East Pit (see Table 5.2.2-49). The mass balance also took into consideration the loss of mercury via burial (i.e., loss due to settling), evasion/volatilization, and outflow (i.e., pumping to the WWTF for treatment and discharge). Category 1 Stockpile drainage was assumed to be unaltered by the waste rock in the stockpile (i.e., no adsorption of mercury to the waste rock), which is a conservative assumption as there is evidence that waste rock likely adsorbs mercury from precipitation. The mass balance model conservatively assumed that mixing only occurred in the upper 30 ft of the water column, as this would limit the volume of water available to dilute the mercury-loading.

Table 5.2.2-49 Initial and Final Parameter Values for the Mercury Mass Balance

Parameter	Flow in Mine Year 60	Total Mercury Concentration or Flux
Wet and Dry Deposition Precipitation (based on monitoring data) [1]	697 acre-ft/yr[1]	13 ng/L; 9,407 ng/m^2/yr[1]
Atmospheric dry deposition	NA	3,093 ng/m^2/yr[1]
Total wet and dry deposition	NA	12,500 ng/m^2/yr[1]
Contained/Uncontained Category 1 Stockpile drainage	0.3 ac-ft/yr[2]	13 ng/L
Watershed runoff (stormwater runoff from undisturbed or reclaimed/revegetated areas; includes the runoff from the Category 1 Stockpile)	30 ac-ft/yr[2]	4 ng/L[3]
Groundwater Inflow (shallow aquifer)	45 ac-ft/yr[2]	3 ng/L[3]
East Pit flow (from wetland)	248 ac-ft/yr[2]	4 ng/L
Backfilled East Pit flow (groundwater) ("lower pore water seepage")	0 [2] (Intermittent contribution; 0.02 to 0.15 ac-ft/yr during pit flooding)	4 ng/L
Treated Water: Mine Site WWTF	0[2] (Up to 588 acre-ft/yr during pit flooding)	8 ng/L
Plant Site Water: Treated water from the WWTP and collected seepage water (untreated) from the Tailings Basin seepage containment systems (supplemental water for pit flooding)	0[2] (Up to 3,500 acre-ft/yr during pit flooding)	1.3 ng/L
West Pit Mercury Losses		
Burial	NA	92% of total load; 12,700 ng/m^2/yr[4]
Evasion/Volatilization (~5% of atmospheric inputs)	NA	5% of atmospheric inputs[5]
Outflows	490 acre-ft/yr[2]	Varies with concentration of West Pit water column

Source: PolyMet 2015m, Table 6-15.

Notes:

1 Precipitation volume from monitoring stations within 30 miles of the NorthMet Project Proposed Action area based on mean annual precipitation (1981-2010 climate normal); annual average mercury concentration from the National Atmospheric Deposition Program for the Fernberg Road Site (MN18) (2010-2011). Total atmospheric deposition is assumed to equal 12,500 nanograms per square meter per year (ng/m^2/yr) (Swain et al. 1992). Dry deposition is set equal to the difference between total and wet deposition and represents about 25% of total deposition.

2 Flow estimate from GoldSim Modeling results.

3 Estimate of mercury concentration based on NorthMet Project Proposed Action data.

4 Burial rate for mercury is lower (more conservative) than initial estimate according to the burial regression equation discussed in PolyMet 2015m.

5 Volatilization rate is estimated based on the low end of the range of values discussed PolyMet 2015m.

Based on the input values from Table 5.2.2-49 above, the estimated average mercury concentration of the West Pit during flooding (years 20 to 52) would initially be approximately 0.3 ng/L, and after flooding (after year 52) would stabilize at approximately 0.9 ng/L.

It should be noted that the West Pit overflow would be treated by the WWTF using RO or equivalent technology known to remove mercury and would meet water quality targets prior to discharge. Therefore, the actual mercury concentrations in the WWTF effluent discharge are expected to be less than the concentrations predicted for the West Pit lake (i.e., less than 0.9 ng/L), although an effluent mercury concentration of 1.3 ng/L was assumed for purposes of estimating mercury concentrations in the WWTF discharge. Table 5.2.2-50 provides a summary of the initial mass balance results, with the largest input of mercury to the West Pit coming from atmospheric deposition (about 66 percent of total estimated inputs), and the largest loss of mercury attributed to burial (about 92 percent of total mercury inputs).

The Overburden Storage and Laydown Area would not be lined, but would have a compacted soil bottom. Unsaturated overburden and peat would be temporarily stored at the Overburden Storage and Laydown Area until it is utilized for reclamation purposes. Some of the temporarily stored organic material would decompose on site, which would release mercury into solution. Any dissolved mercury would be transported in solution with precipitation that falls on the Overburden Storage and Laydown Area (PolyMet 2015r). Any mercury released from the peat decomposition process is thought to be transported with precipitation that falls on the Overburden Storage and Laydown Area. Because the Overburden Storage and Laydown Area would be unlined, there would be some potential for seepage to enter the groundwater system from peat that has decomposed and releases as a pulse of mercury. However, construction of the Overburden Storage and Laydown Area would result in a compacted bed that would limit downward seepage and facilitate routing of water to storage ponds.

Stormwater runoff from the Overburden Storage and Laydown Area would be considered process water which would be routed to the process water pond and eventually collected and routed to the Tailings Basin for years 1 to 11, where much of the mercury would be sequestered in the tailings through sorption. In years 12 to 20, the Overburden Storage and Laydown Area stormwater runoff would be collected and routed to help flood the East Pit, where most of the remaining mercury would be sequestered with waste rock at depth (e.g., through settling and other chemical processes within the pit). Because peat removal from the areas to be mined would be completed between years 5 to 11, any potential release of mercury from stored peat materials would have occurred or would be ending by the time water is routed from the Overburden Storage and Laydown Area pond to the East Pit beginning in year 12. After year 20, the Overburden Storage and Laydown Area would be closed, reclaimed, and material removed, and therefore would no longer serve as a potential source of mercury.

The potential for mercury release from peat decomposition in the Overburden Storage and Laydown Area is included in the mass balance as part of the Process Water input. The mercury load from the Mine Site would slightly decrease during closure and long-term maintenance, because a portion of the flow that is currently watershed yield (total mercury concentration of 3.6 ng/L) would be captured in the West Pit lake and discharged via the WWTF at a conservatively assumed total mercury concentration of 1.3 ng/L. Flows from the Mine Site in closure and long-term maintenance are not expected to change from existing conditions; therefore, the change in total mercury concentration from 3.6 ng/L to 1.3 ng/L for a portion of the flow from the Mine Site results in reduced loading to the Partridge River (Barr 2015g). Therefore, the NorthMet Project Proposed Action is predicted to result in a net decrease in mercury-loading to the Partridge River from 24.2 to 23.0 grams per year, primarily due to a decrease in natural runoff and a proportional increase in water discharged from the West Pit via the WWTF (with a total mercury concentration of 1.3 ng/L).

Table 5.2.2-50 Summary of Estimated Mercury-Loading (Inputs)[1] and Losses (Outputs) for the West Pit Lake (Mine Year 20 to about Mine Year 52)

Parameters	Annual Average Load of Mercury (nanograms)	Percent of Summed Inputs	Comments
Inputs			
Atmospheric (wet + dry)	1.26E+10	66%	Dry deposition ~30% wet deposition
East Pit wetland overflow	9.03E+08	5%	Includes runoff from the East Pit and watershed to the East Pit
Process water (other than from the East Pit)	1.65E+09	9%	Includes runoff from the Category 1 Stockpile
Groundwater	2.74E+08	1%	Includes groundwater flow from undisturbed portions of the Mine Site + groundwater inflow from the East Pit + contained/ uncontained Category 1 Stockpile drainage
WWTF	1.61E+09	8%	
Pumping from the Plant Site: WWTP and collected seepage from the Tailings Basin	2.12E+09	11%	
SUM	1.91E+10		
Outputs (Losses)			
Evasion/Volatilization	6.30E+08	3%	Loss from the water column
Burial	1.76E+10	92%	
Groundwater	NE		
Overflow	2.58E+07	0.1%	
Removal by RO WWTF	NE		
SUM	1.82E+10		
NET (retention)			
Inputs – Outputs	8.73E+08		Net retention of mercury

Source: PolyMet 2015m, Table 6-16.

Notes:
NE = Not estimated for this analysis.
[1] Reasonably conservative estimates of mercury concentrations and average annual flow estimates from GoldSim modeling were used to estimate mercury-loading.

Direct Release of Mercury to the Embarrass River Watershed from the Tailings Basin

The Plant Site would receive inputs of mercury from two primary sources: residual trace concentrations in the tailings and process consumables, with some minor contributions from Mine Site process water, which would be pumped to the Tailing Basin pond through year 11 (and possibly through year 20, but is dependent on the NorthMet Project Proposed Action's water balance). As discussed in Section 5.2.2.3.1, all process make up water used for stream augmentation would be treated at the WWTP prior to discharge. Mercury would be released from the Tailings Basin via seepage, discharge from the WWTP, and volatilization from the Tailings Basin pond (this mechanism is discussed in Section 5.2.7, Air Quality). As with the Mine Site, mercury was not included in the GoldSim model, but a mass balance approach was used to estimate future mercury concentrations.

Several studies have been conducted by state agencies regarding the release of mercury from taconite ore processing and tailings facilities. Berndt (2003) concluded that wet and dry deposition of mercury was the major source of dissolved mercury in taconite tailings pond water, deposition of mercury was the major source of dissolved mercury in taconite tailings pond water, rather than the actual tailings themselves. Further, Berndt found that taconite tailings appear to be a sink for mercury in full-scale actual tailings basins in northern Minnesota, at least similar to other media like soils, as evidenced by lower mercury concentrations in waters seeping from tailings basins (specifically at U.S. Steel's Minntac Mine and Northshore Mining's Northshore Mine) than in either precipitation input or pond water in the tailings basin. The loss of mercury through adsorption to solids in the tailings basin and subsequent burial in the sediments results in an overall permanent retention of mercury within the basin and decreases the mercury load released to receiving waters. Berndt (2003) demonstrates that mercury released to surface waters during taconite processing is insignificant with respect to mercury concentrations found in local precipitation and existing background surface waters. This finding is supported by surface water monitoring around the existing LTVSMC Tailings Basin, which found mercury concentrations in surface water seepage to be consistent with baseline levels (see Table 4.2.2-4), generally averaging less than 2.0 ng/L. The overall average total mercury concentration at two discharge locations at the Tailings Basin (SD-026 and SD-004) over a 9-year period was 1.0 ng/L, indicating relatively low mercury concentrations in the existing LTVSMC Tailings Basin seepage. All monitoring results were well below average concentrations in precipitation, so most mercury appears to be sequestered in the LTVSMC tailings through adsorption (see Table 4.2.2-4).

A mass balance model was developed to aid in estimating potential release of mercury from the Plant Site. All major inputs of mercury were included in the mass balance model. The major outputs of mercury include the hydrometallurgical residue, air emissions from the hydrometallurgical process, the tailings, and the ore concentrate. The vast majority of the mercury is predicted to remain in the concentrate, with only about 8 percent predicted to be sent to the Tailings Basin via the tailings and process water. Process and tailings water samples from a pilot study conducted with NorthMet ore were found to have mercury concentrations of 11.2 and 0.7 ng/L, respectively. Mercury loadings to the Tailings Basin are estimated to be 16.2 pounds per year (lbs/yr), with about 15.8 lbs/yr from solids and about 0.4 lbs/yr from process water. For comparison, this is significantly less than the 610 lbs/yr estimated average mercury-loading to the existing LTVSMC tailings basin during LTVSMC operations.

In 2006, Northeast Technical Services, Inc. (NTS) conducted a bench study using NorthMet tailings to determine the rate of mercury adsorption by the tailings. The study utilized large-volume shake flask tests to evaluate mercury adsorption of tailings over time (PolyMet 2015j). The concentration of dissolved mercury in a treatment flask containing process water and NorthMet tailings decreased from 3.3 ng/L (at time 0) to 0.9 ng/L (at 480 minutes). Although the exact mechanisms behind the adsorption process are not yet clearly understood, the ability of NorthMet tailings to adsorb mercury, in combination with the proven ability of the underlying taconite tailings to adsorb mercury, is expected to result in an overall increase in the adsorption of mercury and subsequent lower concentrations of mercury at the Tailings Basin with the addition of the NorthMet tailings. Although adsorption was not explicitly included in the mass balance model, its effects are observed in the mercury concentrations in runoff from the existing LTVSMC tailings, and are therefore assumed in the modeled future concentrations in Tailings Basin seepage.

In summary, the Tailings Basin is predicted to receive less loading of mercury (about 2 to 3 percent) and less flow than the existing LTVSMC Tailings Basin historically received, while retaining the adsorption benefits of the LTVSMC tailings, as well as the demonstrated mercury adsorption capability of the NorthMet tailings. For these reasons, it is reasonable to conclude that the seepage from the NorthMet tailings should have similar or lower mercury concentrations as the LTVSMC tailings seepage, which has averaged about 1.0 ng/L. Therefore, the total mercury concentration in seepage from the Tailings Basin is expected to be less than the GLI standard of 1.3 ng/L.

During long-term maintenance, the Tailings Basin seepage would be captured and pumped to the WWTP for treatment. The WWTP would also receive water from the Tailings Basin pond, as well as stormwater runoff from the basin. The discharge from the WWTP, like the discharge from the WWTF, would be subject to the GLI standard of 1.3 ng/L. The estimated mercury concentration and flow rate for each of these influent streams is shown in Table 5.2.2-51. As this table shows, the combined influent streams are estimated to have a mercury concentration of 1.3 ng/L prior to treatment.

Table 5.2.2-51 Estimated Mercury Concentration of the Combined Inflows to the Plant Site WWTP

Stream	Flow Rate (gpm)	Mercury Concentration (ng/L)	Total Mercury Flow (ng/yr)
Seepage water	1,635	1.0	3.3E+09
Runoff (interacting with tailings)	290	1.0	5.8E+08
Runoff (not interacting with tailings)	75	3.5	5.3E+08
Tailings Basin pond dewatering	425	2.0	1.7E+09
Combined stream	**2,425**	**1.3**	**6.0E+09**

Source: Table 6-8, PolyMet 2015j.

The WWTP would use a greensand filtration process followed by RO unit or equivalently performing technology that would meet water quality targets. RO treatment or equivalently performing technology that would meet water quality targets are known to remove mercury, particularly when the influent is pre-treated, and this potential additional removal of mercury is not accounted for in mass balance calculations, which adds a level of overestimation to the mass balance results. Any reduction in mercury by the WWTP would reduce discharge concentration; therefore, the total mercury concentration in the WWTP discharge is expected to meet the evaluation criteria of 1.3 ng/L.

The NorthMet Project Proposed Action is predicted to result in a net increase in mercury loadings to the Embarrass River of up to 0.2 grams per year (from 22.3 to 22.5 grams per year), which is about a 1 percent increase. This increase is primarily attributable to:

- The redirection of surface runoff diverted via the drainage swale constructed east of the Tailings Basin East Dam directly to Mud Lake Creek (at an assumed mercury concentration of 3.5 ng/L, versus a seepage concentration of 1.0 ng/L); and
- The Tailings Basin containment systems, which would collect seepage from the Tailings Basin, with an estimated mercury concentration of 1.0 ng/L, and route it to the WWTP, which would discharge with an assumed mercury concentration of 1.3 ng/L, which is considered conservative in that the WWTP and the greensand filter are expected to remove some mercury from the effluent.

Enhanced Mercury Methylation

Virtually all dispersal of mercury in the environment (especially atmospheric dispersal) occurs in inorganic form (Fitzgerald and Clarkson 1991), but nearly all of the mercury accumulated in fish tissue (more than 95 percent) is organic methylmercury (Bloom 1992). Thus, methylation is a key step in bioaccumulation and the uptake of mercury by aquatic biota. Methylmercury can be a product of the methylation of inorganic mercury by sulfate-reducing bacteria, a process that can be stimulated by increased sulfate concentrations in aquatic systems where sulfate is limiting (Gilmour et al. 1992; Krabbenhoft et al. 1998), although recent research has shown that numerous other types of bacteria can methylate mercury (Gilmour et al. 2013). Although, as described above, the NorthMet Project Proposed Action is expected to result in a negligible release of inorganic mercury to groundwater or surface waters and is predicted to meet the 1.3 ng/L discharge evaluation criteria, the potential effects of the NorthMet Project Proposed Action on mercury methylation must be evaluated. Bacteria that cause mercury methylation require an anoxic environment, and consequently methylation occurs in sediments or in anoxic waters rather than in the turbulent well-oxygenated water of a river. Therefore, methylation is unlikely to occur in the Partridge River or Embarrass River water column; however, it may occur in sediments or possibly in anoxic environments downstream.

There are several factors that influence mercury methylation, including total available mercury, organic carbon, temperature, micronutrients required by sulfate-reducing bacteria, sulfate loadings (over the range for which sulfate may be a limiting factor for sulfate-reducing bacteria), lack of oxygen, and certain hydrologic conditions. The NorthMet Project Proposed Action is expected to have little or no effect on most of these factors, but the effects on sulfate concentrations and hydrologic conditions warrants further discussion and are discussed below.

Sulfate Loadings

Research indicates that sulfate-reducing bacteria are the primary mercury methylators in aquatic systems, especially in wetlands (Compeau and Bartha 1985). Biologically available sulfate is believed to be one of several limiting factors for the methylating bacteria (Jeremiason et al. 2006; Watras et al. 2006). Adding sulfate to aquatic systems where sulfate is limiting can therefore stimulate sulfate-reducing bacteria activity, leading to increased mercury methylation as the sulfate is consumed (Gilmour et al. 1992; Harmon et al. 2004; Branfireun et al. 1999; Branfireun et al. 2001). Recent research in northern Minnesota suggests that increased atmospheric sulfate-loading to a peatland can result in increased mercury methylation and export (Jeremiason et al. 2006), but other research suggests that this effect is not linear and diminishes at higher loads where sulfate may no longer be limiting (Mitchell et al. 2008). Heyes et al. (2000) reported a significant positive correlation between methylmercury and sulfate in a poor fen ($R2 = 0.765$, $p = 0.005$) and in a bog ($R2 = 0.865$, $p = 0.022$).

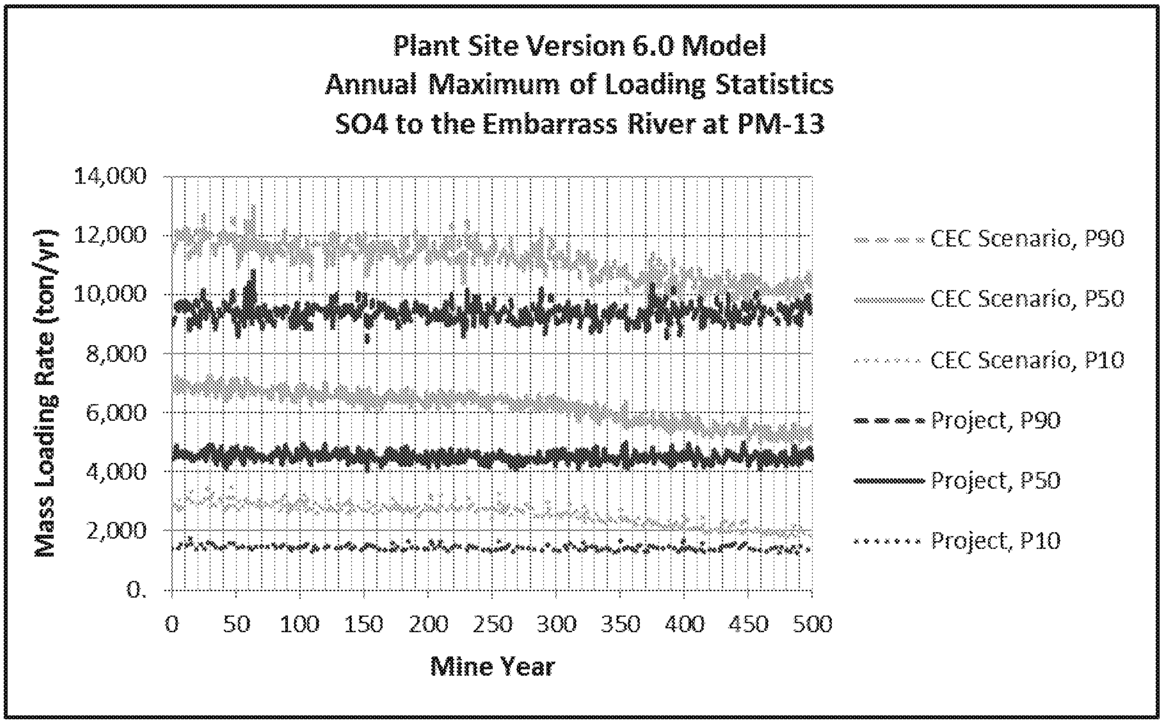
Many studies have shown that wetlands can be sinks for mercury and sources of methylmercury to surrounding watersheds (St. Louis et al. 1996). Galloway and Branfireun (2004) found that wetlands were an important site of sulfate reduction and methylmercury production. Balogh et al. (2004) and Balogh et al. (2006) concluded that increases in methylmercury in several Minnesota rivers during high-flow events was likely the result of methylmercury transport from surrounding wetlands to the main river channel. A recent study by the MDNR found little, if any, correlation between total mercury or methylmercury and sulfate concentrations in northeastern Minnesota streams (Berndt and Bavin 2012a; Berndt and Bavin 2012b; Berndt et al. 2014). Instead, the study found strong correlations between mercury and dissolved organic carbon concentrations and total wetland area. Overall, these studies suggest that most mercury methylation, at least in the St. Louis River Basin, primarily occurs within wetlands rather than in stream channels and the methylmercury is flushed to rivers from wetlands during storm events.

The MPCA and MDNR recognize the important role of sulfate in methylmercury production, as well as the uncertainties regarding site-specific relationships between sulfate discharges and water body impairment. The MPCA has set forth a strategy (MPCA 2006a) for addressing the effects of sulfate on methylmercury production that encompasses technical, policy, and permitting issues. The strategy acknowledges that the technical basis does not exist to establish sulfate concentration limits. The strategy, however, sets forth steps the MPCA can take to improve the technical basis for controlling sulfate discharges and establishes guidance for considering potential sulfate effects during environmental review and NPDES permitting. The strategy focuses on avoiding "discharges," which could include groundwater seepage, to "high-risk" situations. These high-risk areas include wetlands, low-sulfate water (less than 40 mg/L) where sulfate may be a limiting factor in the activity of sulfate-reducing bacteria, and waters that flow to a downstream lake that may stratify, all or most of which apply to the area downstream of the WWTP and the WWTF discharges.

In response to this policy, as well as to comply with sulfate standards that apply to waters previously recommended as supporting the production of wild rice, PolyMet has proposed several significant changes to the NorthMet Project Proposed Action design from that proposed in the DEIS. These changes would significantly reduce sulfate loadings, and include a surface and groundwater seepage containment system around the Category 1 Stockpile and a WWTF to treat the West Pit overflow at the Mine Site and a containment system around the Tailings Basin and a WWTP to treat tailings seepage at the Plant Site.

As a result of the design changes at the Mine Site, the NorthMet Project Proposed Action is predicted to increase the sulfate load by less than 2 percent in the Partridge River watershed, but maintain the same maximum P90 concentration (19.4 mg/L) as the CEC scenario. Effluent from the WWTF would be discharged at a water quality based effluent limit concentration that protects the sulfate standard for waters used for production of wild rice (10 mg/L), beginning when the West Pit is predicted to flood around year 55. Sulfate concentrations in this range coupled with the oxygenated hydrologic environment to which the effluent would be discharged would not be expected to promote mercury methylation.

As a result of the design changes at the Plant Site, the NorthMet Project Proposed Action is predicted to significantly decrease sulfate loadings to the wetlands north of the Tailings Basin and to the Embarrass River, primarily because the containment system would capture nearly all Tailings Basin seepage and ultimately route it to the WWTP, which would treat the seepage and discharge the effluent at a target concentration of 10 mg/L as part of the Embarrass River tributary streams flow augmentation. The net effect of these engineering controls would be a reduction in sulfate loadings relative to the CEC scenario model results at PM-13 (see Figure 5.2.2-56).



Source: Barr 2015j.

Figure 5.2.2-56 Range of Annual Sulfate Loading Rates to the Embarrass River at PM-13 – CEC Scenario versus NorthMet Project Proposed Action

Hydrologic Changes and Water Level Fluctuations

Methylation of environmental mercury by sulfate-reducing bacteria is also stimulated by drying and rewetting associated with hydrologic changes and water level fluctuations (Gilmour et al. 2004; Selch et al. 2007). Drying (and subsequent increase in exposure to oxygen) of substrate containing reduced sulfur species (sulfides and organic sulfur) oxidizes those species into sulfate, which is remobilized and available to sulfate-reducing bacteria upon rewetting of the substrate. This mechanism stimulates production of methylmercury in sediments exposed to wetting and drying cycles (Gilmour et al. 2004) and probably accounts for some of the elevated methylmercury concentrations observed in releases from wetlands during high-flow events (Balogh et al. 2006). Thus, hydrologic changes and water level fluctuations can potentially stimulate mercury methylation and enhance bioaccumulation. The effect of the NorthMet Project Proposed Action would decrease with distance downstream, as can be seen at PM-13, where the maximum change in flow would be approximately 3 percent in the annual average flow during operations, with a closure and long-term maintenance decrease of less than 2 percent (PolyMet 2015j).

Mercury Summary

Based on the above analysis, the NorthMet Project Proposed Action would have negligible effects on hydrologic changes or water level fluctuations in the Partridge River and Embarrass River, would maintain relatively low sulfate loadings and concentrations to the Partridge River, would significantly reduce sulfate loadings to the Embarrass River, and would meet the GLI mercury standard for discharges.

The cumulative MMREM analysis for two scenarios showed a 0.5 to1.8 percent and 0.3 to 0.5 percent potential increase in fish mercury concentration above background. This potential change is considered to be small compared to background levels and is not expected to affect fish consumption advisories or effect consumers of locally caught fish. The increase is not expected to have an appreciable effect on the loading estimates from permitted discharges to the Embarrass, Partridge, or lower St. Louis rivers. Discharges are expected to meet the 1.3 ng/L standard for mercury, with an overall net decrease in mercury loading predicted for the NorthMet Project Proposed Action.

Sulfur is inherent to the mineral matrix of the dust particles that would deposit in the Project area; it is therefore likely that less than 100 percent of the sulfur would be weathered from the particles and be available to go into solution if deposited to soils or water. This potential incremental change may warrant future monitoring, as small sulfate increases in sulfate-poor wetlands would be expected to increase the production of methylmercury in wetlands (Jeremiason et al. 2006). However, methylmercury produced in wetlands is not necessarily incorporated into food chains and concentrated to levels of concern.

Overall, mercury loadings are predicted to increase slightly in the Embarrass River (0.1 percent), and decrease in the Partridge River (1.0 percent). Overall, the changes in total mercury concentrations associated with the NorthMet Project Proposed Action in closure and long-term maintenance at the respective Mine Site and Plant Site are estimated to be too small to distinguish from natural background variability in the Partridge River and the Embarrass River using available laboratory methods (Barr 2015g).

The NorthMet Project Proposed Action and project area watershed information used to assess the potential effects on average annual mercury loading and concentrations at the Plant Site and Mine Site (Upper Embarrass River and Upper Partridge River, respectively) were also used in assessing the potential effects from the NorthMet Project Proposed Action on mercury loading in the St. Louis River. The result would be a net decrease in overall mercury loadings (1.0 grams per year) with no detectable change in mercury concentrations to the St. Louis River as a result of the NorthMet Project Proposed Action (Barr 2015g).

5.2.2.3.5 Proposed and Recommended Mitigation Measures

PolyMet has proposed or agreed to measures to avoid, minimize, or mitigate potential environmental effects. These measures are considered part of the NorthMet Project Proposed Action (see Section 3.2) and include design changes since the DEIS, including fixed engineering controls, PolyMet would be required by its permits to monitor water quality and quantity to refine modeling and to predict future conditions for consideration in permit renewals. In the event that monitoring, coupled with modeling, identifies the potential for water quality exceedances, PolyMet has proposed adaptive engineering controls and contingency mitigation that could be implemented to prevent exceedances of water quality standards. An overview of the evolution of the NorthMet Project Proposed Action with respect to alternatives analysis is provided in Section 3.2.3.3. PolyMet commits to monitoring and management through application of facility management plans that form the NorthMet Project Proposed Action; these plans are listed in Section 3.2.2.

The NorthMet Project Proposed Action mercury air emissions are about 0.16 percent of 2011 estimated statewide emissions and about 0.6 percent of the TMDL statewide target emissions. The NorthMet Project Proposed Action selected a two-stage mercury control system that is expected to achieve 25 percent control for elemental mercury and 90 percent control for particle bound and oxidized mercury (PolyMet 2015e). Because the total mercury control is less than 90 percent, PolyMet moved forward with the remaining TMDL requirement. In addition, PolyMet has conducted a cumulative effects analysis on the local mercury deposition and bioaccumulation in fish (PolyMet 2015e) and the assessment of the cumulative effects is provided in Section 6.2.6.4.3.

The MPCA has conducted a review of the NorthMet Project Proposed Action mercury emissions and has determined that it would not impede the reduction goals (MPCA 2013l). Thus, no minimization and mitigation plan would be required for the NorthMet Project Proposed Action.

5.2.7.2.6 Sulfur Deposition and Potential Indirect Effects on Mercury Methylation

The Ecosystem Acidification report, in support of the Minnesota Steel EIS, indicates that up to 90 percent of the sulfate deposition in Minnesota is due to out-of-state emissions of SO_2 and that sulfate deposition has been on a downward trend since the mid-1980s. Given the current downward trend of sulfate deposition in Minnesota and the relatively small contribution from Minnesota sources to sulfate deposition in Minnesota, the NorthMet Project Proposed Action is not expected to have a measurable effect on sulfate deposition in the state. The trend of decreasing sulfate deposition in Minnesota is expected to continue into the future due to foreseeable regulatory actions that are expected to further reduce sulfur dioxide emissions on a national basis as well as from specific Minnesota sources. A supplemental assessment of the potential additional sulfur from stack and fugitive dust air emissions was conducted to evaluate the NorthMet Project Proposed Action's effects from sulfate as related to mercury methylation and fish concentrations. Sulfur related emissions include SO_2, sulfuric acid mist (SAM), reduced sulfur compounds and sulfur in particulate (e.g., sulfur in the mineral matrix of the ore). Because the estimated Plant Site and Mine Site emissions for each of these are below the PSD permitting thresholds and Significant Emission Rate (SER), no further consideration of these sources were required for environmental impact purposes (Barr 2015f). However, a summary of each is included in Section 4.0 of the document *Mercury Overview a Summary of Potential Mercury Releases from the NorthMet Project and Potential Effects on the Environment* (Barr 2015f). The evaluation estimates the potential sulfur deposition to the Partridge River (Colby Lake) and Embarrass River (Sabin Lake) watersheds and is summarized below.

Sulfur Dioxide

Plant Site stack SO_2 emissions are estimated at about 7 tpy, while stack emissions of SO_2 at the Mine Site are estimated at about 1.9 tpy. The values are too small for PSD air permitting and therefore are not required to be modeled and are not considered to have significant impacts according to the PSD program. Nevertheless, air concentrations of SO_2 were modeled for the Plant Site Class II Air Quality Air Dispersion Modeling Report (Barr 2012j) and can be used to estimate a potential deposition of sulfur related to SO_2 air emissions. Average watershed air concentrations for SO_2 are based on Class II modeling and reflect the Class II modeling receptor grid (Barr 2012j).

Because SO_2 emissions are in the gas phase and are emitted from a taller stack, they tend to disperse further, and therefore represent a more reasonable approximation of a potential air concentration. Additional inputs such as deposition velocity, lake surface area, and water mixing zone were included for evaluation. Based on the results of the modeling, the potential deposition over the Partridge River (Colby Lake) would be 0.003 $g/m^2/yr$ or about 2 percent of background, with a potential surface water concentration from deposition to the lake surface of 0.03 mg/L. The potential deposition over the Embarrass River (Sabin Lake) would be 0.002 $g/m^2/yr$ or about 2 percent of background), with potential surface water concentration from deposition to the lake surface of 0.02 mg/L. With conservative estimates of potential air concentrations and general overestimates of potential deposition associated with screening equations, potential sulfur deposition from SO_2 emissions is a small percent of background sulfur deposition for both the Embarrass River and Partridge River watersheds.

Sulfuric Acid Mist

The revised air concentration estimate for SAM is 0.12 $\mu g/m^3$, as adjusted for the current estimate of SAM emissions of 5.02 tpy (PolyMet 2015e). Additional inputs such as deposition velocity, lake surface area, and water mixing zone were included for evaluation. Based on the results of the modeling, the potential deposition over the Partridge River (Colby Lake) would be 0.0005 $g/m^2/yr$ or about 0.4 percent of background, with a potential surface water concentration from deposition to the lake surface as 0.005 mg/L. The potential deposition and estimated potential incremental sulfate concentration for Embarrass River (Sabin Lake) would also be 0.0005 $g/m^2/yr$ and 0.005 mg/L, respectively. Overall, the deposition from SAM emissions is a small percentage of background sulfur deposition to both the Embarrass River and Partridge River watersheds.

Reduced Sulfur Compounds

Potential NorthMet Project Proposed Action emissions of total reduced sulfur (TRS) compounds, includes hydrogen sulfide (1.88 tpy) and carbon disulfide (5.1 tpy) as estimated to be 6.98 tpy. All of the TRS emissions are from the Plant Site (PolyMet 2015e). No modeling of TRS emissions was required for ambient air quality purposes or the Supplemental Plant Site AERA. However, the potential deposition of sulfur is estimated to be small due to factors such as the ability to remain as a gas under normal environmental conditions, further transport from an emissions source due to oxidation by molecular oxygen and hydroxyl radicals, residence times ranging from 1 day to 40 days, and gas phase at ambient temperatures reacting with photochemically produced hydroxyl radicals (Barr 2015f). Overall, the potential local deposition of sulfur from TRS compounds is uncertain, but it is not expected to exceed evaluation criteria.

Sulfur in Particulate Matter

The estimate of potential sulfur deposition from sulfur in particulate was calculated using the air concentration for the annual averaging time period of 5.8 $\mu g/m^3$ at the Plant Site property boundary (PolyMet 2015e). It is assumed that ore processing would be responsible for all modeled air concentrations. Additional inputs such as deposition velocity, lake surface area, and water mixing zone were included for evaluation. Based on the results of the modeling, the potential deposition over the Partridge River (Colby Lake) would be 0.0045 $g/m^2/yr$ or about 4 percent of background, with a potential surface water concentration from deposition to the lake surface as 0.04 mg/L. The potential deposition and estimated potential incremental sulfate concentration for Embarrass River (Sabin Lake) would also be 0.0045 $g/m^2/yr$ and 0.04 mg/L, respectively. Overall, the sulfur in the particulate and the potential sulfur surface water concentrations would be a small percentage of background deposition for the Embarrass River and Partridge River watersheds.

Based on the results of the additional assessment of sulfur deposition, the potential addition of sulfur from these emissions sources would be small to negligible, and therefore would not be expected to have effects on mercury methylation or fish mercury concentrations. Additional information regarding to mercury methylation is provided in Section 5.2.2.3.4. Mercury deposition and bioaccumulation in fish (PolyMet 2015e) and the assessment of the cumulative effects is provided in Section 6.2.6.4.3.

5.2.7.3 NorthMet Project No Action Alternative

Since this alternative would not involve introducing new emission sources, the NorthMet Project No Action Alternative would have no additional effects on air quality either regionally or locally. Therefore, air quality would be substantially similar to existing conditions.

5.2.7.4 Mitigation Measures

If, during permitting, it is determined that mitigation measures are necessary, the measures described in this section could be considered; however, most of the mitigation measures described are incorporated into the design. PolyMet has proposed the following mitigation measures to reduce effects on air quality associated with GHGs.

5.2.7.4.1 Greenhouse Gas Reduction Measures

Review of Current Mitigation Included In the NorthMet Project Proposed Action

The NorthMet Project Proposed Action incorporates both energy and production efficiency to reduce associated GHGs (Barr 2011e). The potential to minimize and reduce GHG emissions from changes in existing land cover (i.e., release of carbon tied up in terrestrial biomass, soils, or peat and the loss of carbon sequestration capacity from the environment) are also discussed (PolyMet 2015e). The following provides a summary of the reduction measures.

PolyMet proposes a hydrometallurgical process, rather than a pyrometallurgical process, which would result in reduced energy usage. The hydrometallurgical process is expected to reduce the NorthMet Project Proposed Action's energy demand by 50 percent over comparable pyrometallurgical processes. However, while energy use is reduced by one-half, GHG emissions do not decline per unit of production from what would be expected from a pyrometallurgical process, principally because of the large load of non-energy process emissions associated with hydro processing.

PolyMet also proposes to use premium efficiency motors in selected locations rather than standard motors. Motor efficiencies typically vary between 85 and 96 percent, depending upon the size and load of the motor. Gravity transport of process slurries would also be used where possible, instead of pumps. PolyMet proposes to configure the processing plant such that the overall power factor for the facility is as close to one (energy input to energy output) as practical, which would help minimize electricity use.

Ch. 6. Cumulative Effects

From page 6-32. Finally, sulfate and mercury loadings, two key constituents of concern, are predicted to decrease overall as a result of the NorthMet Project Proposed Action. Although sulfate loadings are predicted to increase slightly in the Partridge River Watershed (less than 1 percent) as a result of the NorthMet Project Proposed Action, this is offset by a large decrease in the Embarrass River Watershed (greater than 40 percent at PM-13), resulting in a significant net decrease in overall sulfate loadings to the St. Louis River as a result of the NorthMet Project Proposed Action. Similarly, mercury loadings are predicted to increase slightly in the Embarrass River Watershed (0.1 percent) as a result of the NorthMet Project Proposed Action, but this is offset by a larger decrease (1 percent) in the Partridge River Watershed, resulting in a net decrease in overall mercury loadings to the St. Louis River as a result of the NorthMet Project Proposed Action.

River would stop. This would result in a net reduction in flow to the Embarrass River of approximately 5.0 cfs until the pit floods.

- ArcelorMittal East Reserve Deposit – This is an open-pit taconite mine, which began operations (East Reserve #1) in 2008. The second pit (East Reserve #2) is permitted and is operating as of 2014.

  The first pit has a single permitted dewatering discharge (SD-005) to an unnamed tributary of the Lower Embarrass River (immediately downstream of Esquagama Lake). Pit dewatering discharges from East Reserve #1 averaged approximately 2.7 cfs from 2012 to 2014, but this discharge would likely gradually increase as the pit gets deeper. When discharging, the flow rate is constant, but currently there are several months of the year (primarily in winter) when no discharge occurs. At some yet-to-be-determined point, East Reserve #2 would be opened and pit dewatering would begin through a second permitted discharge (SD-006). The East Reserve Deposit (Pit 1 and Pit 2) would have a combined permitted discharge to the Lower Embarrass River of up to 9.3 cfs, though the actual discharge would likely vary seasonally, and as the mines are developed, at a rate somewhat lower than that. As with the Laurentian Mine, it is important to note that a substantial portion of the permitted discharge replaces natural runoff that is captured by the pit watershed.

- City of Aurora POTW – The City of Aurora withdraws approximately 0.32 cfs from the St. James Pit, a former natural ore pit within the Embarrass River Watershed, and discharges approximately 0.31 cfs of treated wastewater to Silver Creek, which drains to the St. Louis River. Therefore, this withdrawal represents a loss of water from the Embarrass River Watershed of 0.32 cfs.

- City of Biwabik POTW – The City of Biwabik withdraws approximately 0.25 cfs from the Canton Pit for municipal water supply and discharges treated wastewater to a tributary of Embarrass Lake at approximately the same rate. There is effectively no net loss of water associated with the City's water usage.

The net effect of these hydrologic changes would be an approximately 5.2 cfs increase in flow, plus about a 2.6 cfs (operations) to 1.6 cfs (closure) reduction as a result of the NorthMet Project Proposed Action, for a total increase in flow of between 7.8 and 3.6 cfs at the confluence with the St. Louis River, or about 7 percent of average annual flow (assuming an average annual flow of about 117 cfs for a 180.8 square mile watershed with an average annual flow of 0.65 cfs per square mile based on flow at the McKinley gage).

6.2.2.4 Cumulative Effects on Surface Water Quality

This section discusses cumulative effects on water quality for the Partridge River and the Embarrass River.

6.2.2.4.1 Partridge River

Water quality in the Partridge River has been affected by discharges from the Northshore Mine, discharges/overflows from several former LTVSMC pits, and two permitted discharges from Minnesota Power's Laskin Energy Center for decades. As mentioned in Section 5.2.2, the NorthMet Project Proposed Action does not propose any surface water discharges (other than flow augmentation to Second Creek) until the West Pit overflows and the WWTF begins discharging around year 52. However, non-contact stormwater runoff, unrecoverable groundwater seepage from the five groundwater flowpaths (i.e., from the waste rock stockpiles, pits, Ore Surge Pile, WWTF, and Overburden Storage and Laydown Area), and the WWTF discharge would all serve as potential contaminant sources. Stormwater from undisturbed areas of the proposed Mine Site would be similar in chemistry to current runoff from the proposed Mine Site area. The WWTF discharge would be permitted under the NPDES permitting program.

The NorthMet Project Proposed Action is predicted to meet or not cause or add to an exceedance of all surface water quality evaluation criteria at all evaluation locations within the Partridge River watershed for the entire 200-year modeling period. Consequently, there would not be potential cumulative environmental impacts. The scope of cumulative impacts analysis is therefore focused on parameters with a potential to bioaccumulate in aquatic organisms or adversely impact wild rice, an important cultural resource. As a result, the cumulative effects analysis focuses on sulfate (because of its relationship with mercury methylation and wild rice) and mercury (because it is the only parameter on the Partridge River 303(d) list). Mercury is only discussed from a water quality perspective; the potential cumulative effects of the NorthMet Project Proposed Action on the bioaccumulation of methylmercury in fish are discussed in Section 6.2.6.3.3.

Sulfate

Sulfate is a concern along the Partridge River because of the presence of waters supporting the production of wild rice immediately downstream of the NorthMet Project area (including evaluation locations SW-005 and SW-006 immediately above Colby Lake and the portion of the river below Colby Lake). According to available surface water monitoring data, including sulfate sampling conducted as part of recent wild rice field surveys (Barr 2009b, 2011a, 2012a, and 2013m), sulfate concentrations in the Upper Partridge River range from 0.5 to 21 mg/L, which are slightly elevated relative to baseline conditions, assumed to be similar to values in the South Branch of the Partridge River reported in the 1970s (average of 5.2 mg/L). Sampling in Colby Lake found a range of concentrations between 37 and 42 mg/L. Downstream of Colby Lake, sulfate concentrations increase as the result of groundwater seepage into the surficial aquifer from inactive mine pits (e.g., Pit 6 with a sulfate concentration of about 1,200 mg/L) and overflow from inactive mine pits (i.e., Pit 2W, which discharges intermittently at about 4.5 cfs with a sulfate concentration of approximately 125 mg/L). Pit 1 water is discharged October through March with a daily average flow of 7.4 cfs and an average sulfate concentration of 478 mg/L (MPCA, Pers. Comm., March 24, 2015). Pit 2WX, Pit 6, Pit 9, and Pit 9s are not currently discharging surface water. Average sulfate concentrations in the Partridge River in 2013 were 71.3 mg/L at station S005-752, which is just downstream of the confluence with Second Creek at the County Road 110 Bridge. The wild rice surveys found sulfate concentrations as high as 1,100 mg/L in Second Creek.

The baseline sulfate concentrations found in the Partridge River reflect the effects of discharges from existing activities within the watershed. Table 6.2.2-3 summarizes the relative sulfate load contributions from the various identified activities in the watershed. In terms of historic increases in Lower Partridge River sulfate concentration, three important existing loads of sulfate to the Lower Partridge River include the Mesabi Nugget operation, the previous SD-026 seep from the existing LTVSMC Tailings Basin, and the Mesabi Mining Pit 6 seepage, all entering Lower Partridge River via Second Creek.

Table 6.2.2-3 Cumulative Sulfate Loadings to the Partridge River by Activity

Activity	Average Discharge/ Release Rate (cfs)	Representative Sulfate Concentration (mg/L)	Average Sulfate Load (kg/d)
Northshore Mine Operations	2.6	28	178
Northshore Mine Closure	0.0	NA	NA
City of Hoyt Lakes POTW	0.4	~0[(1)]	~0
Mesabi Nugget	7.4 (7 mo.)	473	6,480
Mesabi Mining Site Existing Conditions[1]	0.0	0.0	0.0
Mesabi Mining Project	unknown	unknown	unknown
Laskin Energy Center	-4.2	No change in loading	No addition to ambient load
Cliffs Erie Pits 2/2E/2W	4.5	125.	1,380
Cliffs Erie Pit 3	0.9	74	163
Cliffs Erie Pit 5SW	0.8	85	166
NorthMet Project Proposed Action Plant Site WWTP	0.5 (operations & closure)	10	12.23 (operations & closure)
NorthMet Project Proposed Action Plant Site WWTF	0.65	9	14.3

Sources: PolyMet 2015i; PolyMet 2015r; MPCA 2012l; MPCA 2012m; MPCA 2013h; ; MPCA 2013j; MPCA 2013k; MPCA 2014d; MPCA 2014e; MPCA 2014f; USDOE and MDC 2009, Table 5.3-4; MDNR et al. 2014c).

Note:
1 Does not include the subsurface sulfate contribution from Pit 6, which is likely to have a similar concentration.

Modeling of the NorthMet Project Proposed Action indicates that when the project causes or adds to an exceedance, the magnitude change in concentration is less than 0.9 percent. Therefore, the NorthMet Project Proposed Action should not adversely affect downstream waters that support the production of wild rice (see Tables 5.2.2-31, 5.2.2-44, and 5.2.2-45). The potential cumulative effect of sulfate on mercury methylation in the Partridge River Watershed is discussed below.

Mercury

Based on sampling in studies done for PolyMet, it is estimated that current total mercury concentrations average about 3.3 ng/L in the Upper Partridge River (Barr 2011a) and between 4.6 and 8.7 ng/L in Colby Lake.

Details of the effect of the NorthMet Project Proposed Action on mercury deposition impacts and mercury concentrations are discussed in Section 5.2.7. Table 6.2.2-4 summarizes the relative mercury contributions from the various identified activities in the watershed. Research has found that taconite tailings are effective in sequestering mercury from seepage. Analog data from natural lakes and mine pit lakes in northeastern Minnesota suggest that mercury concentrations generally remain below the GLI's 1.3 ng/L standard, despite precipitation averaging approximately 13 ng/L mercury. Mercury in surface waters undergoes transformations when exposed to sunlight, which can limit its concentration in lakes. For example, methylmercury degrades to soluble oxidized mercury in sunlight, which in turn degrades to elemental mercury, which volatilizes from lakes. Further, much of the mercury in lakes associates with particulate matter, which often settles to the bottom.

The NorthMet Project Proposed Action is predicted to result in a net decrease in mercury loadings to the Partridge River from 24.2 grams per year to 23.0 grams per year. This would primarily be a result of a decrease in natural runoff (with a total mercury concentration of 3.6 ng/L) and a proportional increase in water discharged from the West Pit via the WWTF (with a total mercury concentration of 1.3 ng/L). As discussed above, sulfate concentrations and loadings from the NorthMet Project Proposed Action to the Partridge River are predicted to remain about the same as existing conditions, so the NorthMet Project Proposed Action would not be contributing additional sulfate that could promote mercury methylation. Therefore, the NorthMet Project Proposed Action would not likely contribute to cumulative effects on mercury loading in the Partridge River.

Table 6.2.2-4 Cumulative Mercury Loadings to the Partridge River by Activity

Activity	Average Discharge/ Release Rate (cfs)	Representative Mercury Concentration (ng/L)	Average Mercury Load (kg/d)
Northshore Mine Operations	2.6	0.7	4.5E-06
Northshore Mine in Closure	0.0	0.0	0.0
City of Hoyt Lakes POTW	0.4	7.7	7.5E-06
Mesabi Nugget	7.4	0.6	8.2E-06
Mesabi Mining Site Existing Conditions	0.0	0.0	0.0
Mesabi Mining Project	unknown	unknown	unknown
Laskin Energy Center	-4.2	No change in loading	0.0
Cliffs Erie Pits 2E/2W[1]	4.5	1.0	1.1E-05
Cliffs Erie Pit 3	0.9	0.55	1.2E-06
Cliffs Erie Pit 5SW	0.8	0.55	1.1E-06
NorthMet Project Proposed Action Plant Site WWTP	0.5 (operations & closure)	1.0–1.3	1.2E-06 to 1.6E-06
NorthMet Project Proposed Action Mine Site WWTF (closure)	0.65	1.0–1.3	1.6E-06 to 2.1E-06

Sources: PolyMet 2015i; PolyMet 2015r; MPCA 2012i; MPCA 2012j; MPCA 2012k; MPCA 2013g; MPCA 2013h; MPCA 2013j; MPCA 2014b; MPCA 2014c; MPCA 2014d; MPCA 2014e; MPCA 2014f; MDNR et al. 2014c; MPCA, Pers. Comm., March 24, 2015.;

Note:
[1] Does not include the subsurface mercury contribution from Pit 6, which is likely to have a similar concentration.

6.2.2.4.2 Embarrass River

Section 5.2.2.3.3 contains a detailed discussion of modeled water quality changes in the Embarrass River at PM-13. The placement of the Embarrass River headwaters and Spring Mine Creek on the MPCA 2012 Impaired Waters list indicates that aquatic biota are already under stress in this system (MPCA 2012n). Although stressors have not been identified, the water quality change predicted under the NorthMet Project Proposed Action would have potential to add to these stressors. Therefore, this cumulative effects analysis focuses on sulfate (because of its relationship with mercury methylation and wild rice) and mercury (because it is the only parameter on the 303(d) list). Mercury is only discussed here from a water quality perspective; the potential cumulative effects of the NorthMet Project Proposed Action on the bioaccumulation of methylmercury in fish are discussed in Section 6.2.6.3.3.

Sulfate

Sulfate is a concern within the Embarrass River because of the presence of waters supporting the production of wild rice downstream of PM-13. Present sulfate concentrations in the Embarrass River downstream of the NorthMet Project area are elevated well above natural background levels and currently exceed the wild rice sulfate standard of 10 mg/L. Median sulfate concentration at PM-12, upstream of any historic mining activity, is about 7.2 mg/L compared to a median of about 39.4 mg/L at PM-13. This increase in sulfate concentrations is primarily attributable to the Pit 5NW overflow (average discharge at SD-033 of 1.2 cfs and sulfate concentration of 1,088 mg/L) and seepage from the existing LTVSMC Tailings Basin (average surface and groundwater seepage of 5.7 cfs and a range of mean sulfate concentrations from 109 to 185 mg/L). The combined effects of the Tailings Basin containment system and stream augmentation would reduce the predicted P90 sulfate concentration (see Section 5.2.2.1.3) at PM-13 by about 50 percent relative to the CEC scenario model results.

Considering cumulative downstream effects, the Embarrass chain of seven lakes tend to attenuate the sulfate concentrations by dilution and biological uptake, with concentrations gradually declining in a downstream direction from 21.3 mg/L in Embarrass Lake to 17.1 mg/L at the outlet from Esquagama Lake.

The existing sulfate concentrations in the Embarrass River reflect the effects of discharges from existing activities within the watershed. Table 6.2.2-5 summarizes the relative sulfate load contributions from the various identified activities in the watershed.

Table 6.2.2-5 Cumulative Sulfate Loadings to the Embarrass River by Activity

Activity	Average Discharge/ Release Rate (cfs)	Representative Sulfate Concentration (mg/L)	Average Sulfate Load (kg/d)
City of Babbitt POTW	0.1	37.4	9.1
LTVSMC Area 5NW Pit	1.2	1,088	3,194
ArcelorMittal Mine (Laurentian and East Reserve Mine)	9.3	186	4,232
City of Aurora POTW	0.3[(1)]	NA	NA
City of Biwabik POTW	0.0	0.0	0.0
NorthMet Project Proposed Action Plant Site WWTP	5.7 (operations) 4.3 (closure)	10.0	139 (operations) 105 (closure)

Sources: PolyMet 2014w; MPCA 2012d; MPCA2012i; MPCA 2012j; MPCA 2013g; MPCA 2013h; MPCA 2014c; MPCA 2014d; PolyMet 2015i; MPCA, Pers. Comm., April 29, 2013.

Note:
[1] Discharge is to the St. Louis River.

The NorthMet Project Proposed Action would reduce the sulfate load from the existing LTVSMC Tailings Basin as a result of the containment of tailings seepage by the containment system and subsequent treatment via the WWTP before discharge as part of the tributary stream flow augmentation. This NorthMet Project Proposed Action would result in a greater than 40 percent overall reduction in sulfate loading at PM-13 and would have a positive effect on reducing the sulfate concentration in the Embarrass River downstream of PM-13 (where wild rice is present), the chain of lakes, and the Lower Embarrass River. The Embarrass River at PM-13 would still have sulfate concentrations well above 10 mg/L (see Table 5.2.2-48).

Mercury

The Embarrass River is not on the 303(d) list of impaired waters for mercury impairment; however, several lakes downstream of the NorthMet Project Proposed Action along the Embarrass River are listed for "mercury in fish tissue" impairment, including Sabin, Wynne, Embarrass, and Esquagama lakes. These lakes are not covered by the statewide mercury TMDL, but are impaired waters and in need of a TMDL pollution reduction study. These waters are not included in Minnesota's regional mercury TMDL because the mercury concentrations in fish are too high to be returned to Minnesota's mercury water quality standard through reductions in mercury emissions from Minnesota sources alone. Based on limited sampling in studies done by PolyMet, it is estimated that total mercury concentrations in the Embarrass River averaged 4.8 ng/L at monitoring station PM-12 and 4.0 ng/L at monitoring station PM-13 from 2004 to 2013. Methylmercury concentrations in the Embarrass River averaged 0.5 ng/L at PM-12 and 0.4 ng/L at PM-13 over the same period (see Section 4.2.2.1.4). The overall average total mercury concentration at two discharge locations at the existing LTVSMC Tailings Basin (SD-026 and SD-004) over a 5-year period was 1.0 ng/L, indicating relatively low mercury concentrations in the seepage from this basin. All monitoring results were well below average concentrations in precipitation (approximately 13 ng/L), suggesting that some mercury appears to be sequestered in the existing LTVSMC tailings.

As discussed in Section 5.2.2.3.4, mercury would be released from the Tailings Basin via seepage, discharge from the WWTP, and volatilization from the Tailings Basin pond. As with the Mine Site, analog data and simple mass balance model estimation methods were used to estimate future mercury concentrations. Table 6.2.2-6 summarizes the relative mercury contributions from the various identified activities in the watershed. As discussed in Section 5.2.2.3.4 and above, research indicates that mining itself is not expected to appreciably affect total mercury discharges; rather, the greater concern is the potential for sulfate discharges/releases to promote mercury methylation.

Table 6.2.2-6 Cumulative Mercury Loadings to the Embarrass River by Activity

Activity	Average Discharge/ Release Rate (cfs)	Representative Mercury Concentration (ng/L)	Average Total Mercury Load (kg/d)
City of Babbitt POTW	0.1	2.6	6.4E-07
Cliffs Erie Area 5 NW Pit	1.2	0.93	2.7E-06
City of Aurora POTW	0.3[1]	NA	NA
City of Biwabik POTW	0.0	0.0	0.0
ArcelorMittal Mines (Laurentian and East Reserve Mine)	9.3	1.6	3.6E-05
NorthMet Project Proposed Action Plant Site WWTP	5.7 (operations) 4.3 (closure)	1.0–1.3	1.4E-05 to 1.8E-05 (operations) 1.1E-05 to 1.4E-05 (closure)

Sources: PolyMet 2014w; PolyMet 2015i; MPCA2012i; MPCA 2012j; MPCA 2013g; MPCA 2013h; MPCA 2014b; MPCA 2014c; MPCA 2014d.

Note:
1 Discharge is to the St. Louis River.

The NorthMet Project Proposed Action is predicted to result in a net increase in mercury loadings to the Embarrass River of up to 0.2 grams per year (from 22.3 grams per year to 22.5 grams per year), which represents about a 1 percent increase. This increase is primarily attributable to the redirection of surface runoff diverted via the drainage swale constructed east of the Tailings Dam East Dam directly to Mud Lake Creek at an assumed mercury concentration of 3.5 ng/L (versus a seepage concentration of 1.0 ng/L). The Tailings Basin Containment System, which collects seepage from the Tailings Basin, with an estimated mercury concentration of 1.0 ng/L, routes it to the WWTP, which discharges with an assumed mercury concentration of 1.3 ng/L, which is considered conservative in that the WWTP and the greensand filter are expected to remove some mercury from effluent.

Overall, the NorthMet Project Proposed Action is predicted to result in a net decrease of mercury-loadings of approximately 1.0 grams per year (i.e., a net decrease of 1.2 grams per year in the Partridge River and a net increase of 0.2 grams per year in the Embarrass River), which is too small to distinguish from natural background variability using available laboratory methods. Therefore, the NorthMet Project Proposed Action would not contribute to cumulative effects on mercury loading to the St. Louis River.

6.2.6.4.2 Physical Habitat Effects

Hydrologic changes are often one of the major sources of effects on fish and macroinvertebrate habitat. While many aspects of the hydrologic regime can be important to the maintenance of fish and macroinvertebrate assemblages, reduction in baseflow (the portion of streamflow from groundwater) is particularly relevant because it represents a change or even a loss of habitat.

Section 5.2.6.2 concluded that the NorthMet Project Proposed Action would reduce flow upstream of Colby Lake and in the Embarrass River by very small amounts from the current baseline habitat conditions. Alterations due to multiple projects in the Second Creek Watershed within the Partridge River Watershed along with the planned flow augmentation of Second Creek due to the NorthMet Project Proposed Action may contribute to small cumulative effects on aquatic habitat if flows fluctuate by more than 20 percent, but fluctuations of this magnitude are not expected (see Section 6.2.2). Changes in average annual flow of less than 20 percent would fall into the range of annual natural variability in terms of precipitation and would have minimal impacts to ecosystem function and aquatic species within the Embarrass River Watershed.

After 2070, when Northshore Mine dewatering discharge is predicted to end, there may be effects on the headwater Partridge River instream habitat due to loss of flow. The NorthMet Project Proposed Action, however, would not be expected to contribute measurably to this cumulative effect, but instead would incidentally reduce the effect downstream of SW-004 by discharging treated water in mine year 52.

6.2.6.4.3 Effects from Mercury

Estimated Mercury Deposition

The NorthMet Project Proposed Action, along with other reasonably foreseeable projects have the potential for adverse effects from mercury deposition on nearby lakes, including the Heikkila, Colby, Sabin, Wynne, and Whitewater lakes, the Partridge River and Embarrass River watersheds, and the aquatic biota within these waterbodies.

The cumulative effects of mercury from the NorthMet Project Proposed Action and other cumulative actions on risks to fish consumption were analyzed using the MMREM. As described in Section 5.2.7.2.5, the MMREM assessed the potential changes in fish mercury concentrations in the following nearby lakes (Barr 2015f):

- Heikkila Lake;
- Colby Lake;
- Sabin Lake;
- Wynne Lake; and
- Whitewater Lake.

The five lakes are located within 12 km, about 7 miles, of the Plant Site. Heikkila Lake, Sabin Lake, and Wynne Lake are included in the Embarrass River watershed, while Colby Lake and Whitewater Lake are closest to the Plant Site and are part of the Partridge River watershed. The closer a lake is to the Plant Site, the greater the potential for more effects from deposition related to Plant Site operations.

The MMREM method relies on empirical fish contamination data (Barr 2012b), combined with the principle of proportionality between mercury in fish and atmospheric deposition (MPCA 2006a). As other cumulative analyses have identified that local impacts from mercury deposition are small and likely not measureable in terms of fish mercury concentration within 10 kilometers of a single project, it is expected that projects located further away would have fewer impacts. Consequently, it has been determined that the maximum extent of the quantitative cumulative impact assessments using the MMREM is about 25 kilometers (about 16 miles) from the specific project of interest (Barr 2015f). The analysis considered deposition from the NorthMet Project Proposed Action and the Mesabi Nugget emissions over existing risks. The Mesabi Nugget Large Scale Demonstration Plant was assessed because it is the only "reasonably foreseeable" project within 25 km of the NorthMet Project Proposed Action.

Because of uncertainty in speciation of emissions of the NorthMet Project Proposed Action, two speciation scenarios were used for assessing potential effects for the NorthMet Project (Barr 2015f), while only one scenario was used to evaluate the Mesabi Nugget Large Scale Demonstration Plant emissions since there was no uncertainty in the speciation of the emissions from this action. The first scenario for the NorthMet Project Proposed Action represents a conservative overestimation of oxidized mercury (25 percent elemental mercury, 50 percent oxidized mercury, and 25 percent particle bound mercury), while the second scenario is a more conservative and more likely speciation for air emissions (80 percent elemental mercury, 10 percent oxidized mercury, and 10 percent particle bound mercury) that is considered to provide a worst-case emissions scenario for the NorthMet Project Proposed Action. The scenario for the Mesabi Nugget Large Scale Demonstration plant evaluates 99.3 percent elemental mercury (see Section 5.2.7.2.5).

The current MPCA-estimated mercury atmospheric deposition rate is 12.5 $\mu g/m^2/yr$ for northeast Minnesota (MPCA 2007), which translates into about 250 pounds of mercury currently being deposited onto the St. Louis River Watershed (3,600 square miles) every year due to background deposition. The potential total annual deposition in the watershed from the NorthMet Project Proposed Action is estimated to be about 0.17 pounds per year (Barr 2012b), which is less than 0.1 percent of the estimated 250 pounds per year of mercury already being deposited to the St. Louis River watershed due to background deposition.

The cumulative analysis assessment showed that projected increase in mercury concentrations from the two reasonably foreseeable cumulative sources in the fish for the five lakes ranges from 0.3 to 1.8 percent (when considering both speciation scenarios), of which the increased percentage from the NorthMet Project Proposed Action alone ranges from 0.2 to 1.6 percent. Therefore, although the NorthMet Project Proposed Action would account for the majority of the increase, the total added mercury to the lakes is small compared to background conditions. The highest impact in fish concentration from the NorthMet Project Proposed Action alone was at Wynne Lake where the estimated incremental increase to fish tissue mercury concentration is 0.016 ppm. This estimated incremental change in fish mercury concentration is small compared to the background fish tissue mercury concentrations in Wynne Lake range, which range from

0.35 to 2.06 ppm. The increase to fish tissue mercury concentrations at the remaining four lakes was at or below 0.012 ppm (Barr 2013c) with the background fish tissue mercury concentrations in these lakes ranging from 0.12 ppm in Whitewater Lake to 2.06 ppm in Heikkila Lake (Barr 2015f). These potential increases would not be expected to have an appreciable effect on fish tissue mercury concentrations in the Embarrass River or Partridge River and would not have any effect on the current fish consumption advisories for the respective lakes.

Hazard Quotient

The Hazard Quotient is the ratio of the mercury concentration in fish to a health-based target of 0.2 ppm; a Hazard Quotient greater than 1 exceeds the health-based target. To estimate the potential incremental Hazard Quotient, the incremental methylmercury exposure in mg/kg body weight per day and the reference dose are accounted for in the calculation. The incremental Hazard Quotient calculation in the MMREM Spreadsheet uses the following methodology:

- Incremental daily mercury consumed (mg) = estimated incremental increase in fish mercury due to the Project (mg/kg) x the amount of fish consumed (e.g. 0.142 kg for a subsistence fisher);
- Incremental methylmercury exposure (mg/kg body weight per day) = Incremental daily mercury consumed x 1.07945 / adult body weight (70 kg); and then
- Incremental Hazard Quotient = incremental methylmercury exposure (mg/kg body weight per day) / Reference Dose of 1.00E-04 mg methylmercury/kg body weight per day (i.e., the ratio of the incremental methylmercury exposure divided by the reference dose in the same units).

The maximum incremental cumulative Hazard Quotient from the two reasonably foreseeable cumulative projects over existing fish mercury concentrations is 0.08 for recreational anglers, 0.61 for subsistence/tribal anglers, and 0.54 for subsistence fishers. This is only about a 0.3 to 1.8 percent increase over the existing incremental risk levels, for recreational, subsistence/tribal and subsistence anglers. Of this, the NorthMet Project Proposed Action would contribute approximately 59 to 92 percent of the incremental cumulative Hazard Quotient. Note that the current fish tissue concentration in the five lakes results in Hazard Quotients that exceed 1, leading to the need for the fish consumption advisories currently in effect (see Table 6.2.6-1).

Table 6.2.6-1 Analysis of Existing Hazard Quotients of Cumulative Impacts from Mercury Deposition for Five Lakes following Three Fish-Consumption Scenarios

Lake	MDNR #	Speciation Scenario	Recreational Angler[1] Existing HQ	Recreational Angler[1] Incremental Cumulative HQ	Subsistence/Tribal Angler[2] Existing HQ	Subsistence/Tribal Angler[2] Incremental Cumulative HQ	Subsistence Fisher[3] Existing HQ	Subsistence Fisher[3] Incremental Cumulative HQ
Colby Lake	69024900	Scenario 1	4.3	0.05	32	0.4	28.4	0.35
		Scenario 2		0.02		0.1		0.10
Heikkila Lake	69025300	Scenario 1	3	0.05	22.3	0.4	19.8	0.35
		Scenario 2		0.01		0.1		0.09
Sabin Lake	69043401	Scenario 1	4.7	0.06	35.1	0.5	31.2	0.41
		Scenario 2		0.02		0.1		0.11
Whitewater Lake	69037600	Scenario 1	1.6	0.01	11.9	0.1	10.6	0.09
		Scenario 2		0.01		0.0		0.03
Wynne Lake	69043402	Scenario 1	6.2	0.08	46.2	0.6	41	0.54
		Scenario 2		0.02		0.2		0.15

Source: Barr 2012b.

Notes:
[1] Consumption rate assumed to be 30 grams/ day.
[2] Consumption rate assumed to be 224 grams/ day and approximates the allowed take of fish by a Tribal member (~180 pounds per year of fish).
[3] Consumption rate assumed to be 199 grams/day.

Water Mercury Mass Balance

In addition to atmospheric mercury deposition, water discharges from the NorthMet Project area would affect the mercury load in the Embarrass and Partridge rivers (and ultimately on downstream portions of the St. Louis River). As discussed in Section 5.2.2.3.4, a water mass balance was performed to assess mercury load from NorthMet Project Proposed Action. The mass balance indicated that overall, the NorthMet Project Proposed Action is predicted to result in a net decrease in mercury loading to the St. Louis River watershed and is not likely to result in an appreciable change in the mercury concentration in fish in waterbodies of the St. Louis River watershed, including the Embarrass River or Partridge River, or in the St. Louis River itself (Barr 2015f). Potential mercury increases from air deposition discussed above would not be expected to have any appreciable effect on inputs into the water quality mass loading calculations.

Statewide Mercury TMDL and Mitigation Measures

The MPCA Statewide Mercury TMDL is intended to provide the long-term framework to reduce mercury in fish within Minnesota lakes, including the five lakes targeted in this assessment. The MPCA and industries emitting mercury into the atmosphere are working to reduce Minnesota sources' contribution to fish contamination. Minnesota is relying on actions by other states and the USEPA to address deposition from long-range sources.

In the period of time between completion of the cumulative effects analysis background study for Minnesota Steel and the development of this FEIS, Minnesota stakeholders created an implementation plan for Minnesota's mercury TMDL (MPCA 2009c). Within the implementation plan, there is a process for assessing new and expanding sources of mercury in Minnesota. It is important to assess sources so that while existing sources reduce emissions, new sources do not interfere or confound the state's progress in reducing mercury emissions overall. At the recommendation of the Minnesota stakeholders, MPCA has developed guidance for new and modified sources of mercury in Minnesota (MPCA 2013d). The guidance requires sources to: employ best controls to reduce mercury emissions and apply emissions limits to permit conditions. MPCA has conducted a review of the NorthMet Project Proposed Action mercury emissions and has determined that it would not impede the reduction goals (MPCA 2013l). Thus, no minimization and mitigation plan would be required for the NorthMet Project Proposed Action (see Section 5.2.7.2.5). Mercury mitigation measures are summarized in Section 5.2.2.3.5 (water) and in Section 5.2.7.4 (air).